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SPECULATIVE SCIENCE.

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"*Wenn ein Kopf und ein Buch zusammenstossen, und es klingt hohl, muss es denn immer das Buch gewesen sein?*"—LICHTENBERG, *the Physicist.*

THE above title is prefixed to an article contributed by Professor Simon Newcomb to the April number of the "International Review." The avowed object of that article is to discredit a recent volume of the "International Scientific Series" ("The Concepts and Theories of Modern Physics") as a publication unworthy of the company in which it appears, and to denounce its author as a person ignorant of the subject whereon he writes—as a scientific, or rather unscientific, "charlatan" and "pretender" belonging to the class of "paradoxers" whom Professor De Morgan has immortalized in his famous "Budget." I am fully aware that, as a rule, it is both unwise and in questionable taste for an author to make direct reply to criticism, however hostile, baseless, or absurd. The merits of a book must find their vindication, at last, in its contents, and the chief function of the critic is to bring them to the attention of the reader, the value and spirit of the critical performance being of secondary importance. But the case in hand appears to me to be an exceptional one. The unmistakable intent of Professor Newcomb's "criticism" (and, if it be left unchallenged, its probable effect) is to signalize the contents of the book with which he deals as mere drivel, and unworthy of a moment's serious attention. And he writes for a magazine, the majority of whose readers, however intelligent they may be, can hardly be expected to possess that familiarity with the matters under discussion which is a necessary prerequisite to the formation of an independent and trustworthy judgment. All they are likely to know and care is,

that Professor Newcomb is a prominent scientist, at the head of a scientific bureau in Washington; while the author of the book he professes to review, if known at all, is known only in connection with pursuits which are generally supposed to preclude, not only distinction but even reputable standing in the domains of scientific investigation. I take the liberty, therefore, to subject the strictures of my critic to a counter-critical examination, trusting that the learned professor himself will find it thorough, and that the reader who has not only perused his article, but also looked into a chapter or two of my book, will recognize it as neither impertinent nor unfair.

Whatever may be thought of the soundness or unsoundness of the general argument of the little book in question, the drift of that argument, it seems to me, can hardly be mistaken by the reasonably intelligent reader. What I attempt to show is simply this: that modern physical science aims at a mechanical interpretation of physical phenomena, seeking to effect a reduction of them to two elements which are ordinarily designated as *matter* and *motion*, but which (for reasons briefly stated in the book, but to be stated more at length presently) are more correctly designated as *mass* and *motion*. I then attempt to show that, if to these premises we add the assumption of the atomic constitution of matter, the mechanical theory necessarily involves four distinct propositions, relating severally to the equality, inertia, and inelasticity of the atoms or ultimate molecules and the essentially kinetic character of what is now universally termed energy. In order to enforce the irrecusability of these propositions on the basis of the atomo-mechanical theory, and to guard against the imputation that I am engaged in the frivolous pastime of chopping logic, I am at pains to show, in the next four chapters, that every one of these propositions is insisted on and propounded in terms identical with, or equivalent to, those in which I state them, by men whom I was under the delusion, up to the time of the appearance of Professor Newcomb's article, of regarding as persons of the highest scientific authority—such men as Professors Du Bois-Reymond, Thomas Graham, Wundt, etc. I then proceed to inquire what is the relation of these propositions to the sciences of chemistry, physics, and astronomy, as they are actually constituted, endeavoring to ascertain whether or not the fundamental propositions of the atomo-mechanical theory are available as theoretical solvents of the facts with which these sciences are conversant, and whether or not they are consistent with them. The result of this inquiry is, that the man of science, however emphatic he may be in the general assertion that all physical phenomena are due to the interaction of atoms or ultimate molecules, is constrained by the data of scientific experience to repudiate and discard the propositions which his assertion necessarily involves. It thus appears that there is conflict between the facts and working hypotheses or theories of the sciences on the one hand and the atomo-mechanical theory on the

other; that the latter theory fails in the presence of the facts, and that all attempts to remove this conflict have, thus far at least, been abortive.

After supplementing these preliminaries by a discussion of the atomic theory and its dependant, the kinetic theory of gases, I approach the problem whose solution is the sole aim of my little treatise, which, as is expressly stated in the very first sentence of the preface, is designed as a contribution, not to physics or metaphysics, but to the theory of cognition. That problem is the determination of the logical and psychological origin of the mechanical theory, and of its attitude toward the laws of thought and the forms and conditions of its evolution. It is neither necessary nor practicable here to attempt a reproduction of the tenor of my discussion. It is sufficient for my present purpose to state my conclusion, which is, that the mechanical theory with all its implications is founded on a total disregard or misapprehension of the true relation of thoughts to things or of concepts to physical realities; that, so far from being a departure from and standing in antagonism to metaphysical speculation, the propositions which lie at its base are simply exemplifications of the fallacies that vitiate all metaphysical or ontological reasoning properly so called. There is hardly a page in the book, after the first two expository chapters, in which my utter repudiation of the mechanical theory and its fundamental assumptions is not conspicuous. My objections to this theory are stated in so many ways, and are enforced by so many considerations, that my position in regard to it appears to me insusceptible of misapprehension even by the most hebetated intellect. During the last six weeks I have received more than twenty letters from various persons—most of them mathematicians and physicists, but a few of them persons without scientific training—in which the doctrines of my book are discussed or questioned, sometimes on grounds which indicate that my meaning has been strangely misapprehended. But not one of these letters gives rise to the least suspicion that the writer was mistaken as to my attitude toward the mechanical theory.

And now, what does Professor Newcomb represent my position to be? The reader who has not seen his article will be amazed when I tell him that, according to him, my book was written for the purpose of *maintaining* the propositions of the atomo-mechanical theory, and of subverting the whole science of physics by means of them, on the principle, I suppose, that if the facts do not agree with the theory, so much the worse for the facts! Here is Professor Newcomb's language:

> The author's criticism is wholly destructive; where he constructs it is only to destroy. It is true that his first chapter on the atomo-mechanical theory lays down certain propositions already mentioned which he seems to hold as true. He makes use of them to destroy the whole fabric of modern physics, and show physical investigators generally to be the subjects of miserable delusions. But

his last chapter is devoted to showing that this theory is itself a failure, so that, when he takes his leave, we have nothing left to contemplate but a mass of ruins.

It is curious to note the introduction of the word "seems" into this passage—as the lawyers say, its appearance with a *semble*—while in other places, e. g., where Professor Newcomb speaks of the proposition that molecules are inelastic as my "favorite doctrine," or where he charges me (after reading my tenth chapter!) with ignorantly confounding the "abstract noun" *mass* with the concrete term *matter*, he makes no such qualification.

Having satisfied himself (no doubt before writing his article, though the conclusion is stated most explicitly toward its close) that I am in the lists as a champion of the atomo-mechanical theory and as the dogmatic defender of its fundamental propositions, he proceeds to assail these propositions, sometimes with what he seems to regard as an argument, but generally with a sneer. The contents of my introductory chapter, consisting almost exclusively of citations from the writings of Professors Kirchhoff, Helmholtz, Clerk Maxwell, Ludwig, Du Bois-Reymond, etc., he brands as "propositions in which we can trace neither coherence nor sense." The thesis that, on the basis of the atomo-mechanical theory, all potential energy is in reality kinetic—the distinct proposition of Professor P. G. Tait, who asserts it as the unavoidable consequence of the atomo-mechanical theory of gravitation—he "passes over as not even worth quoting." Similarly the doctrine of the essential passivity of matter—also a proposition of Professor Tait, whose exact words I quote on page 306 of my book—is flouted with the disdainful remark that "such words as 'active' and 'passive' have no application in the case and serve no purpose, except to produce confusion in the mind of the reader." In this way he levels his thrusts at the most eminent physicists and mathematicians of the day, laboring always under the hallucination that he is striking at me.

Among the most characteristic performances of Professor Newcomb are his strictures, already adverted to, on my substitution of the term *mass* for the word *matter*, in designation of the substratum of motion in the light of the atomo-mechanical theory. According to him, this use of the word *mass* is evidence of my ignorance and intellectual confusion, as well as of my "total misconception of the ideas and methods of modern science." He informs me that the word *mass* is "an abstract noun like *length*," whereas I use it "as a concrete term, and in *nearly* the same sense as we commonly use the word matter." And thereupon he delivers himself of a dissertation (which resembles nothing so much as a sermon of "Fray Gerundio" to his "familiars") on the necessity of using scientific terms only in accordance with their exact definitions, of ascertaining the meanings of the words *mass* and *motion* by a reference to the methods whereby they are measured, and

so on. All this is certainly strange news to an author who has devoted several chapters of his book to the task of showing that the great fundamental vice of the mechanical theory is the confusion of concepts with things, and particularly of the connotations of the concept *mass* with the complement of the properties of *matter*—who, in a word, is guilty of the great offense of expressing, in the precise terms of the science of logic, what Professor Newcomb is staggering at with a phrase borrowed from some elementary treatise on grammar!

And here I am tempted to do a little Gerundian preaching myself, Professor Newcomb being, of course, my congregation of "familiars." Here is my sermon: *Hombre sabio y admirado*, scattering supernal wisdom, like hurling thunder-bolts, is a prerogative of the dwellers on Olympus, not to be usurped by a drag-footed philosopher bellowing at its base. *Quod licet Jovi, non licet bovi.* I do not mean to question your general ruminant powers; but you have delivered yourself of some things "that have not been well digested," and had better be chewed again. Let me see how I can help you. Listen: When we speak of matter, we mean something which not only has weight, proportional to its mass, but which has all manner of properties—optic, thermic, electric, magnetic, chemical, and so on. Now, in the light of modern science, all these "properties" are regarded as *modes of motion*, if I may be permitted to use the expression of Professor Tyndall. And when we strip matter (in thought, you understand) of all these modes of motion, we have nothing left but *inertia*, which is but another name for mass. This mass is not a concrete thing, but a concept or a part of a concept; it is, as you say, "an abstract noun like length." And the trouble with the atomo-mechanical theorists is their fancy that this abstraction is a thing in itself, something you could look at if you had a telescope with sufficient magnifying power, or which you could weigh and measure if you had a pair of scales or a chemical reagent sufficiently delicate. They labor, as you see, under a huge mistake, which, in charity, ought to be corrected. Whenever you find real matter, you have *mass* and the modes of motion in indissoluble synthesis and conjunction. But when this synthesis is broken by the destructive analysis of the mechanical theorist who persists in saying that things consist of *matter* and motion, you are bound to tell him that what he calls *matter* is not matter at all, but only something which, by a curious law of our thought, we are bound to conceive or imagine as a substratum of motion—the word *substratum* being a barbarous Latin term which in a rough way signifies what is supposed to underlie motion. The term *matter*, as used by those deluded people who think that all the facts of this world can be explained by a resolution of them into matter and energy, or matter and motion, denotes simply what the physicist who knows what he is talking about calls *mass*.

And now, mind, what I have just told you is not some shallow con-

ceit hatched under my own time-tonsured pate, but genuine wisdom which I have simply borrowed from an old, clear-headed fellow, who lived and died a long while ago—Leonhard Euler. If you will read his seventy-fourth letter to a German princess, written on the 11th day of November, 1760, you will find it all set forth at great length. In reading it you must bear in mind, though, that in Euler's time the imponderables, as they were then called, were not so distinctly known or believed to be modes of motion as they are now. And you must also remember that he was writing to a princess who probably knew more about madrigals and operatic airs than about scientific terms, in consequence whereof his exposition became a little diffuse. If, however, you should reject old Euler's reasoning as "belonging to a past age of thought," which, I see, is one of your favorite ways of getting rid of irrefutable truths, I may refer you to a gentleman who is yet among the living—Hermann Helmholtz. You will find what he has to say on the "matter in hand," on the third and fourth pages of his first essay, "Ueber die Erhaltung der Kraft" (not included in the collection of his essays).

Now, *hombre querido* (I am still preaching), if after this you will carefully read again the first twelve chapters of my book, you will probably find that they are somewhat less absurd than you fancied they were. But you will say, no doubt—in fact, you *do* say, though not in so many words—that all this is mere speculative trash, in which the man of science has no concern. One of my reviewers in the New York "Critic"—whom I at one time suspected, perhaps unjustly, from certain peculiarities of his phraseology, and from the fact that, like yourself, he sneers at me for having "wasted" two long chapters on transcendental geometry, of having had oral confabulations with you, in which the mouth of the speaker was not and could not be applied to the ear of the listener—disposes of my discussion of the relation of the mechanical theory to the laws of thought by the following oracular dictum (a travesty of a saying of Carlyle): "A sound digestion has little self-consciousness of the operations of the stomach; the sound thinker gives himself little uneasiness respecting the laws of thought." I can not stop, at this moment, to show you how and why a little knowledge of the laws of thought is useful to the physicist and mathematician. I shall come to that by-and-by, when I have considered what you say about the kinetic theory of gases and space of an indefinite number of dimensions. For the present I only want to tell you how I ventured upon the audacity of intruding the theory of cognition into the science of physics.

In Europe, as well as in this country, there are certain idle fellows who, during the first half of the present century, for want of more useful occupation, took to tracing the ramifications of forms of speech, and finally got to digging for their roots. These absurd persons abound chiefly in Germany, where, as you know, the people are always

in the nebular regions, when they ought to be fighting and grubbing on the solid ground below. In course of time these individuals, despite the utter fatuity of their undertaking, persuaded themselves that they were engaged in something important, and became noisy and presumptuous. At one time they even clamored for admission into the ranks of the physicists and astronomers, on the ground that they had discovered phonetic and other laws, which they claimed to be as immutable as the laws of Kepler. Their application was, of course, scornfully denied, for the reason that they were either no scientists at all, or at best speculative scientists. Instead of submitting humbly to this just decree of the physicists (it is a pity they had not my present meekness before them as an example), these men grew wrathy and turned away with something like this objurgation: "Well, never mind, the time is not far distant when you will come as suppliants to us." And, thereupon, in sheer malice, having got well-nigh through with the roots and branches of words, they fell to attacking the history of their meanings—of concepts, as they called them—pretending to make legitimate employment of inductive methods, which they wholly misapprehended, no doubt, and which, at any rate, were among the clear prerogatives of the physicists. And now they pretend to have established, *inductively*, a number of laws relating to the operations of the intellect, which they again assert to be immutable, and, though controlling acts of consciousness, to be wholly independent of deliberate intent or set purpose. They say, for instance, that there runs throughout the history of speculative as well as of ordinary thinking an almost irrepressible tendency to hypostasize concepts, or (as I have called it, cribbing an outrageous barbarism from Professor Bain) to *reify* them. I will try to explain to you what that means, as nearly as possible in your own words. When people make or find a new "abstract noun," they instantly try to put it on a shelf or into a box, as though it were a thing; thus they *reify* it. In very early times they did worse than that—they undertook to incase it in a smock-frock or a pair of breeches. They *personified* it. There was a still earlier period when, worst of all, men blasphemously and impiously *deified* abstractions; and it is said that this class of persons has not wholly died out yet.

Now, the silly speculators I have just alluded to have already divided the science they pretend to be cultivating into several branches, to which, being word-mongers, they give all sorts of sesquipedalian names, such as comparative linguistics, comparative psychology, comparative mythology, and so forth. To give you an idea of the temerity of these pseudo-scientists, let me tell you that one of them, Professor Max Müller, of Oxford—who is, of course, a German—at one time undertook to account for the monotheism of the Jewish race by a peculiarity of Semitic speech. It is even whispered that he and others, years ago, evolved the whole city of Troy, with all its houses and

walls, the heroes within it, with their wives and children, as well as the Greek warriors and their ships, without it—everything, including the Trojan horse and what it contained—from a parcel of solar myths, demonstrating to their own satisfaction that all these persons and things were, at bottom, nothing more than "objectivations" of forms and laws of speech. As was to be expected, this fine theory came to grief when Schliemann appeared with a pickaxe and spade. As usual, the theory collapsed in the presence of the facts. Be that as it may, there is one thing these scientific pretenders persist in asserting, in spite of all their past discomfitures: that more than three fourths of the controversies in theology and metaphysics have had their rise in the ignorance of the fathers of the Church, and of mediæval and modern scholastics, of the results brought to light in these new-fangled sciences. Unfortunately, when I was less old and wary than I am now, I fell in with these "paradoxers," some of whom I knew to be men of great learning, and believed to be persons of thorough earnestness of purpose. To my astonishment I found two mathematicians among them—Hermann Grassmann and Franz Woepcke. I had read with some difficulty, but, as I thought, with reasonable grasp of his meaning, the "Ausdehnungslehre" (since supplemented by a new treatise under nearly the same title, and a number of articles in Crelle's and Borchardt's "Journal") of Grassmann; and I had attempted to read some of the writings of Woepcke, though without success, because he went far beyond my depth. But I got an impression that both had things to say—in mathematics, at least—that were worth knowing; and inferred that there must be sense and purpose also in their linguistic endeavors. In this way I became interested, and gradually caught the spirit of the comparative linguists and mythologists by contagion. And so it came to pass that, after a while, I asked myself this question: "If the results of these sciences are available for the solution of the perplexities of the metaphysicians, why may they not also throw some light on the nature of our perplexities in physics?" So far as I could learn, no one had attempted an orderly and systematic answer to this question, although (as is not unusual in cases of this sort) there was a considerable amount of scattered material ready to the hand of whomsoever should undertake the work. Under these circumstances, I was fool-hardy enough to make an attempt myself, the result being my poor little book. And now I confess I am not a little mortified at being informed that I am a "learned and able" idiot; and I derive but scant comfort from the assurance that my mental predicament may be accounted for on the theory of contagion, and that the hypothesis of congenital imbecility may be avoided.

But it is time to doff my Gerundian robes and to cease apostrophizing the familiars, for I have things to say which ought to be said in all earnestness and sobriety. I am about to examine Professor

Newcomb's animadversions on my chapters on the kinetic theory of gases and transcendental geometry. On the former he expatiates as follows:

> For the benefit of the non-scientific reader we may say that there is no theory of modern physics, the processes supposed by which are invisible to direct vision, which is more thoroughly established than this. It explains with the utmost simplicity and without introducing any but the best known properties of molecules, a great number of diverse phenomena, seemingly incapable of explanation in any other way. The only objection of the author which we can completely understand is that the theory in question—i. e., the kinetic theory of gases—seems to him incompatible with his own favorite doctrine that molecules are inelastic. Should he have any hesitation in pitting his *a priori* idea against so widely received a theory, it should relieve him to know that the supposed antagonism arises only from his own misapprehension. *No elasticity is assigned the molecules in the kinetic theory, but only an insuperable, repulsive force which causes the molecules to repel each other when they are brought sufficiently near together.* The reader who has any interest in following the author in his attempt to show that Maxwell and his colaborers were guilty of a long series of fallacies and errors in attempting to prove the theory in question, may read the chapter, as an abstract is impossible.

So "no elasticity is assigned to the molecules in the kinetic theory." Well, that is startling news indeed! I hope it has been conveyed to Sir William Thomson, who at latest accounts was still engaged in the arduous, but, as we are now informed by Professor Newcomb, utterly useless study of vortex-rings, which he hopes to make available as substitutes for elastic atoms or ultimate molecules. At the last meeting of the British Association Sir William Thomson read a paper "On the Average Pressure due to the Impulse of Vortex-Rings on a Solid," of which an abstract is published in "Nature" for May 12, 1881 (vol. xxiv, pp. 47, 48). In this paper Sir William says:

> The pressure exerted by a gas composed of vortex-atoms is exactly the same as is given by the ordinary kinetic theory, *which regards the atoms as hard elastic particles.*

I do not deem it necessary to multiply quotations from the writings of other scientific men in support of my statement that the kinetic theory of gases can not dispense with the assumption of the elasticity of ultimate molecules. No intelligent reader who has glanced at page 42 of my book can be in any doubt as to what is taught on the subject by the founders and promoters of the theory in question. But I will add one citation, because it is from a book to which I shall have occasion to refer for another purpose. The most thorough mathematical treatise on the kinetic theory of gases, indorsed as such by Clerk Maxwell, is the well-known little book of Henry William Watson. It is in the form of propositions; and the very first words of the first proposition are these:

A very great number of smooth, *elastic* spheres, equal in every respect, are in motion within a region of space of a given volume, and therefore occasionally impinge upon each other with various degrees of relative velocity, and in various directions.

The italics in this passage, as well as in all past and future quotations, are mine.

In justice to Professor Newcomb, however, we must look at his entire sentence, which is this: "No elasticity is assigned to the molecules in the kinetic theory, *but only an insuperable, repulsive force, which causes the molecules to repel each other when they are brought sufficiently near together.*" This information, Professor Newcomb hopes, will "relieve me." I am indeed relieved! What the learned professor tells me in the last part of his sentence certainly simplifies matters to the last degree. All that needs be assigned to the molecules is an "insuperable repulsive force." Such a force is the greatest convenience for the physicist that can possibly be devised; it not only effects a simple and satisfactory solution of the difficulties set forth in my fourth and eighth chapters, but it enables us at once to get over every other difficulty that may be suggested. It is singular that Sir Isaac Newton did not understand this when he was distressed about the mechanism of gravitation; for, obviously, all that is required to explain it is to assign to the molecules an *attractive force.* Sir Isaac's ignorance is all the more remarkable because, coming to think of it, I now recollect that the philosophy of which Professor Newcomb is the able exponent was very clearly set forth, just fourteen years before the appearance of Newton's "Principia," in a profound metaphysical treatise published by one Jean-Baptiste Poquelin (otherwise called Molière) under the somewhat whimsical title "Le Malade Imaginaire." Toward the close of that great work (which is in the form of dialogues), one of the interlocutors, Bachelierus, philosophizes as follows:

"Mihi a docto doctore
Domandatur causam et rationem quare
Opium facit dormire.
A quoi respondeo
Quia est in eo
Virtus dormitiva
Cujus est natura
Sensus assoupire."

Of course, we are not to be embarrassed by anything John Bernoulli has written about "insuperable forces" as mathematical or physical functions; nor is it worth while to be disturbed by considerations respecting the effect of their assumption upon the doctrine of the conservation of energy.

Professor Newcomb's indignation at my treatment of the kinetic theory of gases is very great indeed. "There is no theory of modern physics," he says, "the processes supposed by which are invisible to

direct vision, which is more thoroughly established than this. *It explains with the utmost simplicity, and without introducing any but the best-known properties of molecules, a great number of diverse phenomena seemingly incapable of explanation in any other way.*" Now, it is a great pity that these glad tidings did not reach Professor Clerk Maxwell before he was laid to rest in his early grave. They would certainly have been a great comfort to him, and possibly might have prolonged his life. For there is reason to suspect that in his latter days he arrived at conclusions respecting the kinetic theory of gases which bear a strange resemblance to my own. Being, not a scientific dogmatist, but an honest and candid investigator in search of truth, he came to see with ever-increasing clearness that the difficulties of his favorite theory beset not only its fundamental assumptions, but also their inevitable consequences, especially in their bearings upon the theory of heat. After the appearance of Watson's treatise already adverted to, on the 26th day of July, 1877, he published in "Nature" (vol. xvi, No. 404) a review of it, in which he considered the significance of Mr. Watson's propositions in connection with certain matters discussed on pages 97, 99, and 127 of my book. And thereupon he made this declaration ("Nature," vol. xvi, p. 245) :

> The clear way in which Mr. Watson has demonstrated these propositions leaves us no escape from the terrible generality of his results. Some of these, no doubt, are very satisfactory to us in our present state of opinion about the constitution of bodies, but there are others which are likely to startle us out of our complacency, *and perhaps ultimately to drive us out of all the hypotheses in which hitherto we have found refuge into that state of conscious ignorance which is the prelude to every real advance in knowledge.*

I hope, by-the-way, that this last remark of the great scientist will be pondered by those who complain that, after demolishing, as they imagine, all current physical theories, I leave them in the midst of ruins, and do not at once present them with a golden key for unlocking all the mysteries of the universe, or, like Puck, in "Midsummer-Night's Dream," "put a [theoretical] girdle round about the earth in forty minutes."

Before I leave this subject, I take the liberty of quoting another passage from the same article, which Professor Newcomb, if he knows *anything* about the discussions to which the kinetic theory of gases has given rise, will find instructive. Speaking of Boltzmann's attempt to reconcile the elasticity of atoms with their rigidity by increasing their co-efficients of elasticity *ad infinitum*, so as to make them practically rigid—a supposition also developed in an essay of Hugo Fritsch in Königsberg, entitled "Stoss zweier Massen unter der Voraussetzung ihrer Undurchdringlichkeit behandelt," which does not seem to have fallen under Professor Maxwell's notice (and, I may add, a supposition of which Professor Newcomb's "insuperable force" may

be a vague reminiscence)—Maxwell says ("Nature," vol. xvi, pp. 245, 246):

But, before we accept this somewhat promising hypothesis, let us try to construct a rigid-elastic body. *It will not do to increase the co-efficients of elasticity without limit till the body becomes practically rigid.* For such a body, though apparently rigid, is in reality capable of internal vibrations, and these of an infinite variety of types, so that the body has an infinite number of degrees of freedom.

The same objection applies to all atoms constructed of continuous, non-rigid matter, such as the vortex-atoms of Thomson. Such atoms would soon convert all their energy of agitation into internal energy, and the specific heat of a substance composed of them would be infinite.

A truly rigid-elastic body is one whose encounters with similar bodies take place as if both were elastic, but which is not capable of being set into a state of internal vibration. We must take a perfectly rigid body and endow it with the power of repelling all other bodies, but only when they come within a very short distance from its surface, but then so strongly that under no circumstances whatever can any body come into actual contact with it.

This appears to be the only constitution we can imagine for a rigid-elastic body. And, now that we have got it, the best thing we can do is to get rid of the rigid nucleus altogether, and substitute for it an atom of Boscovich—a mathematical point endowed with mass and with powers of acting at a distance on other atoms.

But Boltzmann's molecules are not absolutely rigid. He admits that they vibrate after collisions, and that their vibrations are of several different types, as the spectroscope tells us. But still he tries to make us believe that these vibrations are of small importance as regards the principal part of the motion of the molecules. He compares them to billiard-balls, which, when they strike each other, vibrate for a short time, but soon give up the energy of their vibration to the air, which carries far and wide the sound of the click of the balls.

In like manner, the light emitted by the molecules shows that their internal vibrations after each collision are quickly given up to the luminiferous ether. If we were to suppose that at ordinary temperatures the collisions are not severe enough to produce any internal vibrations, and that these occur only at temperatures like that of the electric spark, at which we can not make measurements of specific heat, we might, perhaps, reconcile the spectroscopic results with what we know about specific heat.

But the fixed position of the bright lines of a gas shows that the vibrations are isochronous, and therefore that the forces which they call into play vary directly as the relative displacements, and, if this be the character of the forces, all impacts, however slight, will produce vibrations. Besides this, even at ordinary temperatures, in certain gases, such as iodine gas and nitrous acid, absorption bands exist, which indicate that the molecules are set into internal vibration by the incident light. The molecules, therefore, are capable, as Boltzmann points out, of exchanging energy with the ether. But we can not force the ether into the service of our theory so as to take from the molecules their energy of internal vibration, and give it back to them as energy of translation. It can not in any way interfere with the ratio between these two kinds of energy which Boltzmann himself has established. All it can do is to take up its own due proportion of energy according to the number of its degrees of freedom. We leave it

to the authors of "The Unseen Universe" to follow out the consequences of this statement.

I may safely take it for granted after this, I presume, that, while Professor Newcomb may have a vocation for expounding and defending the kinetic theory of gases, he has no special call, as he supposes, to stand up for Clerk Maxwell and his opinions.

It is hardly necessary to say that Professor Newcomb does not honor my objections to the kinetic theory of gases with any notice or attempt at refutation. He observes that "an abstract of them is impossible," which is to be regretted, for, if he had undertaken to give us one, we should undoubtedly have learned some noteworthy things. The task of making such an abstract does not appear to be very difficult. What I insist on is, that every valid physical theory is essentially a simplification and not a complication, a reduction of the number of unrelated facts which it undertakes to account for, and not a mere substitution of many arbitrary assumptions of unknown and unverifiable facts for a few known facts—that is to say, speaking in the language of mathematics, that every true physical theory is in effect a reduction of the number of independent variables representing the phenomena to be explained. And I show that the kinetic theory of gases not only fails to satisfy this requirement, but is a complete reversal of a legitimate scientific procedure. This is the sense of the passage which Professor Newcomb parades before the unwary reader, whom he ought to have shocked still more with my horrible suggestion (which I now deliberately repeat) that a gas is in its nature a simpler thing than a solid, and that no attempt to account for its properties by taking those of a solid as a basis and making arbitrary additions to them is likely ever to succeed.

It is not a little instructive to note the character of sacredness ascribed by persons of Professor Newcomb's frame of mind to dominant physical theories, and the violence with which they repel every attempt to point out their defects. My reviewer in "The Critic" is almost beside himself after reading my "assault" on "that magnificent fabric of science, the undulatory theory of light and heat." Before he pelts me again with his missiles, he will do well to look and see who is standing at the place to which he directs them. There is at Harvard University a most learned and laborious scientist whose merits as an original investigator are at least equal, if not superior, to his inestimable services as an expounder of scientific truth, and the extent of whose attainments is no less conspicuous in his memoirs and books than the clearness of his intellect—Professor Josiah P. Cooke, Jr. In May, 1878, Professor Cooke published a lecture on the radiometer in this journal ("Popular Science Monthly"), in which he had occasion to speak of the undulatory theory of light and the luminiferous ether. And there (pages 11, 12) we find this language :

But turn now to the astronomers, and learn what they have to tell us in re-

gard to the assumed luminiferous ether through which all this energy is supposed to be transmitted. Our planet is rushing in its orbit around the sun at an average rate of over 1,000 miles a minute, and makes its annual journey of some 550,000,000 miles in 365 days, 6 hours, 9 seconds, and $\frac{6}{10}$ of a second. Mark the tenths; for astronomical observations are so accurate that, if the length of the year varied permanently by the tenth of a second, we should know it; and you can readily understand that, if there were a medium in space which offered as much resistance to the motion of the earth as would gossamer threads to a race-horse, the planet could never come up to time, year after year, to the tenth of a second.

How, then, can we save our theory, by which we set so much, and rightly, because it has helped us so effectively in studying Nature? If we may be allowed such an extravagant solecism, let us suppose that the engineer of our previous illustration was the hero of a fairy-tale. He has built a mill, set a steam-engine in the basement, arranged his spindles above, and is connecting the pulleys by the usual belts, when some stern necessity requires him to transmit all the energy with cobwebs. Of course, a good fairy comes to his aid, and what does she do? Simply makes the cobwebs indefinitely strong. So the physicists, not to be outdone by any fairies, make their ether indefinitely elastic, and their theory lands them just here, with a medium filling all space, thousands of times more elastic than steel, and thousands on thousands of times less dense than hydrogen gas. There must be a fallacy somewhere, *and I strongly suspect it is to be found in our ordinary materialistic notions of causation*, which involve the old metaphysical dogma, "*nulla actio in distans*," *and which in our day have culminated in the famous apothegm of the German materialist*, "*Kein Phosphor, kein Gedanke.*"

If my reviewer will compare this passage with what I have said on the undulatory theory, he will, perhaps, discover that my observations are at least proof against the charge of frivolity and irrelevancy. And it is not necessary to add, I hope, that it is no more my intention than that of Professor Cooke to call upon the physicist to throw away the undulatory theory as a working hypothesis before he has a better one.

I now come to Professor Newcomb's reflections on my discussion of transcendental geometry. Here are some of them:

In considering the author's work in detail, we begin with the subject of transcendental geometry, or hyper-geometry, as it is sometimes called. We do this because his criticisms are so readily disposed of. He speaks of the "new geometrical faith"; of the "dispute" between the "disciples" of the transcendental or pangeometrical school and the "adherents" of the old geometrical faith; of the "champions" of the old geometrical creed; of the "doctrine" of hyperspace. To the refutation of these supposed erroneous doctrines he devotes no less than sixty-two pages. Now, all his criticism is founded on an utter misapprehension of the scope and meaning of what he is criticising. We make bold to say that no mathematician has ever pretended to have the slightest evidence that space has four dimensions, or was in any way different from what is taught in our familiar system of geometry. He has not been an adherent or champion, or held any doctrine on the subject. Now and then it is barely possible that a physicist might be found—Zöllner, for instance—suggesting such a thing in a moment of aberration. But the great mass of men in their senses remain unaffected by any such idea.

Again:

Whatever we may say of the utility of such investigations, one thing is certain—they are perfectly harmless. At the very worst they can do no more injury to scientific conceptions than the careless author of an elementary algebra will do his pupil by loading an hypothetical baker's wagon with more loaves of bread than the baker could get into it. If Judge Stallo had taken up a book on algebra, found a problem the answer to which required five thousand loaves of bread to be carried by a single baker, and had devoted sixty-two pages to an elaborate statistical and mechanical proof that no wagon could possibly hold that number of loaves, his criticisms would have been as valuable and pertinent as those which he devotes to his imaginary school of pangeometry.

After reading these passages I am sorely perplexed. When Professor Newcomb penned them he had before him my extracts (in a note to page 211 of my book) from the Exeter address of Professor Sylvester, embodying a reference to the speculations of Professor Clifford, and another independent citation from Clifford's writings on page 213. And, being himself a writer on geometry of more than three dimensions, he can hardly have been ignorant of the many other pangeometrical speculations respecting the necessity of assuming the existence of a fourth dimension for the purpose of explaining certain optic and magnetic phenomena. There are mathematicians and physicists in Europe—excellent mathematicians and physicists, too—who maintain that space must have at least four dimensions, because without it a reconciliation of Avogadro's law with the first proposition of the atomo-mechanical theory is impossible. According to them, experience shows that matter has not only *extension* but also *intension*, which directly evidences the actual existence of a fourth dimension in space. Among those who advocate views like this is Professor Ernst Mach, in Prague. How, in the face of all this, Professor Newcomb could have the hardihood to assure his readers that no mathematician has ever pretended that space has more than three dimensions, I am at a loss to understand.

But it is not worth while to quarrel with him on this head; *for his statement, that I devote sixty-two pages to the attempt at proving that space has in fact but three dimensions, is a pitiful misrepresentation, akin to the statement that I am the defender of the propositions of the atomo-mechanical theory.* In my two chapters on transcendental geometry there is not a page, not even a line, devoted to such an undertaking. I discuss two main questions: first, whether or not it is true, as Lobatschewsky, Riemann, and Helmholtz assert, that space is a real thing, an object of direct sensation whose "properties," such as the number of its dimensions and the form or degree of its inherent curvature, are to be ascertained by observation and experiment—by telescopic observation, for instance; and, secondly, whether or not the empirical possibility and character of several kinds of space can be deduced *a priori* from the concept of an n-fold extended multiple,

or from the abstract concept "quantity," using this term as comprehending both algebraic "quantities" and geometrical magnitudes. As subsidiary to these questions I also discuss certain minor questions, such as that of the representability of non-homaloidal forms of space; but upon the proof that there is actually no such thing as non-homaloidal or four-dimensional space I do not waste a syllable. In other words (which Professor Newcomb may find more intelligible, perhaps): my first inquiry is, not whether any one has ever discovered a fourth dimension or an inherent spatial crook by looking through a telescope, but whether there would be any use or sense in trying to make such a discovery by looking through a telescope, even if we could get a base-line large enough to meet the requirements of Professor Helmholtz; and my second inquiry is, whether or not there is any world-producing potency in an algebraic formula or an "abstract noun."

Professor Newcomb claims that investigations respecting geometry of more than three dimensions are at least harmless, and even useful, inasmuch as "they have thrown a flood of light on the origin and meaning of geometrical axioms." My answer to this is, that speculations of this sort are harmless only so long as it is not pretended that they can teach us anything respecting either empirical reality or empirical possibility. And they can throw light on the origin and meaning of geometrical axioms only by giving us an insight into the nature of the forms or modes in which the world of objective reality is or may be reproduced in the intellect. But what shall we say, then, about the grin at speculation in science which stares at us from the very title of Professor Newcomb's article? If he may throw a flood of light on the foundations of geometry, by speculating about space of four dimensions, am I to be jeered at when I endeavor to direct a feeble ray from the general theory of cognition on the same subject—when I try to do methodically what he is doing at random, and without the least suspicion that anything more is necessary for the accomplishment of his purpose than skill in the handling of an analytical formula? It may be that my undertaking has not been very successful; but *in magnis voluisse sat est.* And this leads me to say a few words in answer to the intimation of Professor Newcomb and the direct charge of my reviewer in "The Critic," that inquiries into the forms and laws of thought are sheer impertinence, and of no consequence to the physicist.

In the introductory part of his article Professor Newcomb flings at me the case of De Morgan's paradoxer Smith, who fancied that he could prove the ratio of the circumference of a circle to its diameter to be exactly $3\frac{1}{8}$, by getting somebody to admit that the ratio of the circumference to the diameter is the same for all circles, and then telling him to draw *one* circle with the diameter 1 and circumference $3\frac{1}{8}$. Now, the intellectual plight of this paradoxer, who, besides assuming the very thing to be proved, failed to see that his argument would

serve equally well to establish any other ratio, and who never thought of asking himself the question whether or not a diameter 1 and a circumference $3\frac{1}{8}$ were compatible—whether or not his postulates were consistent with each other—is closely analogous to the mental predicament of certain scientific specialists who are constantly multiplying forces, superable and insuperable, and all manner of entities, with impossible or contradictory properties, for the purpose of explaining natural phenomena. When this is done with a proper insight into the nature and use of such fictions—with the understanding that they are mere devices for fixing ideas or colligating facts (to use Whewell's expression)—it is well enough. But, in many cases, the specialists have no such insight. They begin to treat the fictions here spoken of as undoubted realities, whose existence no one can question without subjecting himself to a Newcombian fustigation. Take the case of the ether, the hypothetical substratum of luminar undulations. It is first mentioned simply as a fluid of the greatest tenuity, as wholly inappreciable to the senses, and as offering no resistance to atoms or celestial spheres. Thereupon, to meet the exigencies of the undulatory theory, it is endowed with a co-efficient of elasticity thousands of times greater than that of steel. Next, at the demand of some physicist or chemist, who wants to incase his atoms or molecules in ethereal atmospheres or envelopes, it is made as soft and mobile as hydrogen gas. First, it is looked upon as continuous; then, to explain the dispersion of light, it is made discontinuous, and "finite intervals" are interposed between its atoms. But now comes Clerk Maxwell, and shows that, if the constitution of the ether were atomic, consequences would ensue upsetting the whole theory of heat; or Helmholtz and Sir William Thomson, in order to be able to construct their vortex-atoms, require it to be absolutely frictionless and incompressible, and therefore continuous; and, accordingly, it is restored again to its ancient continuity, no matter what may become of Cauchy's theory of chromatic dispersion or Fresnel's theory of polarization. Originally there is but one ether; but presently Professor Norton contends that the luminiferous ether is not available for the purpose of explaining the phenomena of electricity and magnetism. He demands a second ether, filling the same space with the first; and his demand is complied with. In a short time Mr. Hudson appears with the claim that even the phenomena of light can not be accounted for on the supposition of a single light-bearing ether; and he must have *two* luminiferous media, "each possessed of equal and enormous self-repulsion or elasticity, and both existing in equal quantities throughout space, whose vibrations take place in perpendicular planes; the two media being mutually indifferent, neither attracting nor repelling"—and, again, his request is granted without further ceremony. To cap the climax, finally arrives the pangeometer, and insists that back of and behind all these ethers there is an independently real thing, an object of direct sensation,

space, which is probably flat, but which possibly may turn out to be inherently crooked. And now, when somebody shakes his head and proposes to examine whether there is not something wrong with this whole mode of philosophizing, which mistakes crutches for limbs, and scaffolds for buildings, Professor Newcomb hurls a wooden thunderbolt at him, or a reviewer in the New York "Critic" reminds him that "the sound thinker gives himself little uneasiness respecting the laws of thought."

Now let us look for a moment at the atom. The physicist or chemist gets it originally as an ancient heir-loom, handed down from the times of Democritus or Lucretius. It is a solid body, with attachments of hooks and loops. The modern scientist takes off the attachments, and holds on to the main solid body, polishing it for his use. So this body becomes round; but in course of time appear the mineralogist and chemist with their morphological laws, such as the law of Mitscherlich, with theories of polarity or valency, or what not; and to accommodate them it is proclaimed that the atom is a cube or a rhomb or an octahedron, or whatever else will silence the most clamor. After a while, Kroenig or Clausius declares that, in the interest of his kinetic theory of gases, he must insist on the perfect sphericity of the atoms or ultimate molecules; and thenceforward (for a month at least) they are spherical. But, at the expiration of the month, Maxwell points to certain anomalous facts which are supposed to be inconsistent with atomic sphericity, and he suggests that it be modified so as to give the atoms the form of oblate or prolate spheroids; and, of course, his suggestion is adopted. In a short time some physicist rushes out of his laboratory or study, and announces that he has just obtained experimental results or arrived at theoretical conclusions requiring an utter rejection, not only of the definite figure of the atom, but of its entire bulk; and forthwith it is subtilized into a mere center of force. But now the physicist is reminded that force must have a substratum, and that its indispensable correlate is inertia. At this juncture the pangeometer flits upon the scene, and offers the perplexed physicist his fourth dimension in which to lodge both the extension and "intension"—i. e., mass—of the centers of force, assuring him that he may have the mere punctuality of the atom in ordinary space, and behind it, in space of four dimensions, any amount of bulk and weight. At this stage of the proceedings the physicist begins to look desperate; perhaps he is silently meditating the question, What is to become of experimental research if the properties of things can vanish *ad libitum*, and retire into the recesses of the pangeometrical regions? And yet, woe to him who ventures to suggest to the chemist that the origin of the trouble is not in his retorts, but in the sincipital alembic through which all his results are at last distilled, or to show the physicist that there is no defect in the lenses of his microscope, but great want of achromatism in those of his intellect! He speedily learns that the

stupid arrogance of dogmatism, which it is the special function of science to repress, has some of its most vulgar representatives in the ranks of those who claim to be, not only votaries of science, but its chosen protagonists and defenders.

Some years ago Fechner, in the first edition of his "Atomenlehre," printed an answer he had made to some one who objected to the theories of the physicists about atoms, ethers, forces, and so on. It was something like this: "I have a handful of coins. You are not pleased with the effigy and inscription, and advise me to throw them away; yet you offer me nothing to replace them but an empty purse." If that speech had been made to me, I should have met it with this reply: "The mischief is that your coins are spurious; they are base metal. Nevertheless, they may serve a good purpose as mere counters or tokens, provided you never lose sight of the fact that they are nothing more. But experience teaches that you *do* constantly lose sight of that fact, and in a short time insist dogmatically that the coins are of unquestionable intrinsic value. And, having found out that you can manufacture any amount of them at little expense, you do what all inflationists and debasers of the currency are in the habit of doing: you flood the market with stuff which must inevitably bring ruin upon the very man whom you have ensnared into the belief that he can never have enough of it, viz., the laborer who is employed in the hard work of producing the material out of which science is to be constructed. So, if you are unable to procure genuine theoretical specie to represent the scientific wealth you are intent on accumulating, and at the same time are unwilling to restrain your propensities for manufacturing spurious coin and palming it off on yourself and others as sterling cash, you had better carry your facts about in baskets or bags, and resort to the ancient clumsy method of barter."

I will not weary the reader by drawing upon the rich store-house of theoretical chemistry for further illustration of the manner in which provisional and tentative hypotheses are paraded as absolute finalities, and results of experimental research are obscured instead of being irradiated by theoretical conceits. I will content myself with a single further reference to a very recent and very remarkable exemplification of the proneness of the very ablest men of science to multiply entities and confound modes of physical interaction or forms of intellectual apprehension with indestructible things.

In the scientific journal, "Nature," for May 26, 1881 (vol. xxiv, p. 78), there is a communication from Professor Silvanus P. Thompson, containing an extract from the preface to his then forthcoming book "Elementary Lessons in Electricity and Magnetism," in which he says:

> The theory of electricity adopted throughout is, that electricity, whatever its nature, is one, not two; that electricity, whatever it may prove to be, is not matter and is not energy; that it resembles both matter and energy in one respect, however, in that it can neither be created nor destroyed.

Accordingly, Professor Thompson supplements the doctrines of the "Conservation of Matter" and "Conservation of Energy" with the new doctrine of the "Conservation of Electricity," which, indeed, is the title prefixed to his communication.

There are, of course, thoughtful physicists (and their number is increasing from day to day) who do not share the delusion that every momentary device for sorting and grouping facts is to be hailed as a new scientific revelation, and who do not dream of calling upon any one to uncover his head before every passing conceit as though it were an eternal truth. But, unfortunately, these men are not always in the high places, and are averse to obtruding themselves in public as vindicators of the authority of science.

I certainly cherish sentiments of the sincerest admiration and respect for the high-minded and generally modest men who devote their energies to the extension of the bounds of knowledge, and, in the interest of thorough and effective work, shut themselves up in narrow and dingy workshops from whose windows a wide survey of the scientific horizon is difficult or impossible. And I appreciate fully the impropriety of troubling and interrupting them with idle and frivolous criticisms and suggestions. I know that they are under the necessity of arranging and combining their crude materials upon such principles and hypotheses as they have at hand—that they can not make bricks without straw. But when a scientific specialist appears as an intruder in discussions for participation in which his habitual occupations have tended, not to qualify, but to disqualify him; and when, instead of listening and saying what he has to say respectfully, he turns to the crowd and vociferates about "charlatans," "pretenders," and "paradoxers," my thoughts involuntarily run into the words of an old Greek which have been stored in my memory since my boyhood days:

Ος δέ κε μητ' αὐτὸς νοέῃ μήτ' ἄλλου ἀκούων
Ἐν θυρμῷ βάλληται, ὸδ' αὖτ' ἀχρήϊος ἀνήρ.

THE EYE-LIKE ORGANS OF FISHES.

By Dr. ERNST KRAUSE.

ONLY a few biological studies can count on so general an interest as those which concern the diversities in the sense-life of animals. We wonder at the stories of snails and mussels that have ears in their feet, or on their backs, or in the folds of their mantles, or which, like the Argus of mythology, have many eyes, or which have eyes on all their limbs; or of those creatures which, like some fishes, have organs of taste all over their skin; or of animals on which have been discovered nervous organs that do not seem to relate to any of

our recognized sensorial functions, but rather point to some sixth sense, unknown to us. To this class belong the phenomena presented by a group of bony fishes, living for the most part at extreme sea-depths, classified in the three related families of the *Scopelids*, *Sternoptychids*, and *Stomiatids*, which have lately received attention from naturalists. They are generally small fishes, often only an inch or less in length, and have on either side of their belly a row of bright spots, extending from the snout to the tail, that might be said to look like a double row of pearl-buttons fastened upon their skin-coat. Sometimes a third row is found extending from the head to the anal fin; and frequently single spots, often of considerable size, are scattered over the head and gills and over the sides of the fish. Several ichthyologists—among them B. Rafinesque, of Palermo; Delle Chiaje, of Naples; Risso, of Nizza; and Cocco, of Messina—have had their attention drawn, since the first decade of the century, to specimens of those creatures that have occasionally been washed ashore in storms; and the more recent deep-sea investigations have made several allied forms known. The old ichthyologists apparently never examined the spots very carefully, but simply described them as silvery mottles or light points. Leuckart seems to have given them the first critical examination in 1864, in *Chauliodus Sloani*, *Stomias boa*, and *Scopelus Humboldtii*, and came to the opinion from it that they might possibly be regarded as supplementary eyes. Ussow, of Moscow, published a paper in 1879 on the structure of the so-called eye-like spots in *Chauliodus*, *Stomias*, *Astronesthes*, *Gonostoma*, and *Maurolicus*, in which he expressed the conclusion that the spots in the

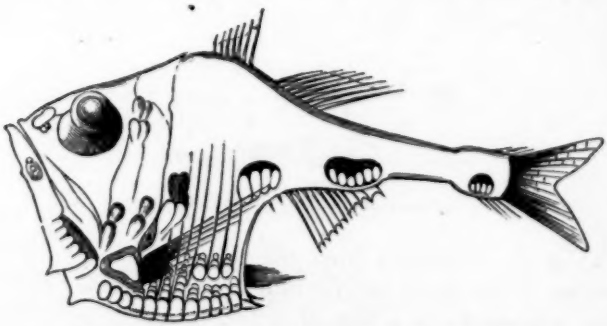

FIG. 1.—*Argyropelecus hemigymnus*, twice the natural size.

three first-named genera were real organs of sight, but that the structure of those in the other genera was of a quite different nature, and really glandular. In the same year Leydig published a work on the *Chauliodus Sloani*, in which he admitted the similarity of the spots of that species to eyes, but was disposed to regard them as transitional organs rather than as real eyes, and referred to one of his observations as indicating that they might have been luminous in life. Leydig has more recently examined ten other species of the families *Sternopty-*

chidæ and *Scopelidæ* (from specimens preserved in spirit), and has considerably advanced the solution of the question of the office of these organs.

The organs in the *Sternoptychids* and the *Scopelids* show essential differences in structure, and a third type has been noticed in some scopelids. Hence, Leydig has described three classes of organs, consisting—1. Of eye-like organs; 2. Of organs of a glass-pearly appearance; and, 3. Of luminous organs. These three forms can be easily distinguished with a glass. The organs of the first class resemble brownish sacks filled with a gray matter; those of the second class brown-bordered, plate-shaped depressions, the ground and edges of which are covered by a film with a metallic luster; and those of the third class, confined to the genus *Scopelus*, present themselves as larger spots of a silvery luster, or a grayish pearl-color.

The eye-like organs—which we have already spoken of as arranged in rows along both sides of the lower central line of the body—are also found on the head about the nose and eyes, on the lids and skin of the gills, and, in the genus *Chauliodus*, in groups of much smaller spots within the cavities of the mouth and gills. The number of the spots, which hardly ever exceeds a hundred in the other genera, rises in this genus to a thousand and more. Their outward appearance is not quite the same in the different parts of the body, but passes from the form of a round sack to that of a cylinder; and some spots are of the shape of a bell or an ampulla. In the genus *Argyropelecus* (Fig. 1) the organs are grouped. They consist of an integument of brown

FIG. 2.—*Ichthyococcus ornatus*, twice the natural size.

pigment, which is coagulated from the thick skin and forms a ring-fold, or gather, dividing the interior into a forward and hinder part. Within this integument is a film of a bright metallic luster, which either underlies the whole of it, or only forms a belt at the mouth, and consists of iridescent threads or spangles lying in the thick skin. The gray inner mass is divided into two sections, a larger hinder part filling the sack, and a smaller forward part. The hinder part is always spherical, the forward part cylindrical, and the two together form a connected whole. To both parts appertains a radial striation proceeding from a frame-work that is continued within from a membrane inclosing the gray mass. The longitudinal section of the hinder part of the organ superficially resembles the cross-section of an orange. We have to deal here, however, not with a few pervading radiations, but with a hollow cone of radiations meeting in the center, a certain

number of which stream out over the spherical circumference of the sack, and fill the neck-part debouching without, so as to give the figure of a cone of rays sunk into the sphere. The net-work is, like that of the orange, filled with small cells, a part of them strongly refracting the light, which pass toward the common point of radiation of both divisions into an opaque granular substance. A nerve is always present in the neck-region of this organ, the fibers of which appear to be lost in the granular midst of the spherical section whose exact histological relations have not been ascertained. Externally, the whole organ is inclosed in a lymph-chamber.

The glass-pearly organs are also distributed over the sides of the belly, the head, the gill-flaps, and the skin of the gills, and the three on the skin of the gills are always longer than the others. They are of the shape of a round disk a little sunken, with a body having a metallic

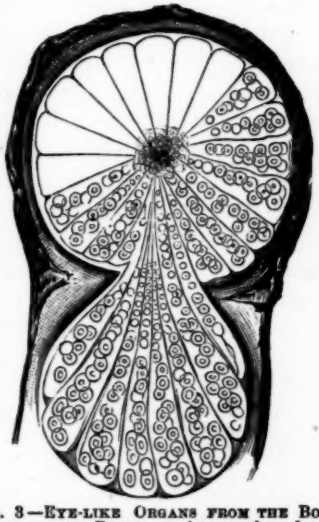

FIG. 3.—EYE-LIKE ORGANS FROM THE BORDER OF THE BELLY OF *Argyropelecus hemigymnus;* longitudinal section, greatly magnified.

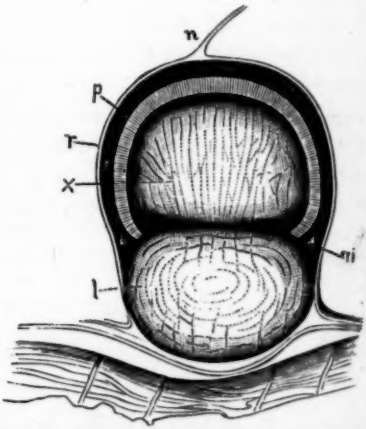

FIG. 4.—LONGITUDINAL SECTION OF THE EYE OF *Stomias anguilliformis* (after Dessow), with the parts designated thus: interior vitreous substance (*x*); lens (*l*); retina (*r*); pigment layer (*p*); iris-like fold (*ir*), and optic nerve (*n*), greatly magnified.

luster and overlaid with a curved transparent integument. An outer brown film of pigment is always present, with a layer of closely joined, regular, hexagonal plates, and a latticed jelly-tissue of delicate, radiated cells that form a net-work, and are lifted up under a roof-like, spiral-shaped concretion (Fig. 5). The nerve-bundles are also present. Quite similar, but distinguished chiefly by their larger size, is the structure of the so-called luminous organs which are present in the *Scopelus Rafinesquii* and *Scopelus metopoclampus* as brightly glittering, well-defined spots above the nasal openings and under the eyes, and which in *Scopelus Humboldtii* and *Scopelus Benoitii* exhibit the form and appearance of depressed pearl-spots.

Concerning the nature of these organs, Leydig denies that any of them are glandular, although Ussow admits that this may be the case with some of the fishes. The hypothesis that they are organs of a sixth sense has received no confirmation. There remains, then, the theory proposed by Leuckart, Ussow, and Leydig, and accepted by Semper as undoubtedly correct, that they are real subsidiary eyes, like the eyes of mussels, etc. Leuckart and Ussow believed that they were able to distinguish a lens, a vitreous substance, and a retina, and the latter has published drawings of those parts; but the careful examinations of the structure of the organs and comparisons between it and the eyes of mollusks have led Professor Leydig to doubt this opinion; for he has observed that, when the fish swims horizontally, the mouths of the supposed eyes are turned, not toward the light, but downward, toward the dark bottom. Still less do the glass-pearly organs resemble eyes. Leydig is rather disposed to believe that he can with great probability recognize an identity in their structure with that of the electric and pseudo-electric organs of some fishes, particularly in the jelly-tissues and the disposition of the nerve-endings. According to this view, each of the disks would in itself correspond to a chest of the electric organs. The round shape of the disks may be explained by their isolated situation, there being no pressure of one upon another to make them angular. A similar diversity prevails in the form of the electric and pseudo-electric organs to that existing in the organs which we are considering, while the homology of the two is strikingly expressed in their similar situation and distribution. Leydig believes that two series of formations of this kind have been devel-

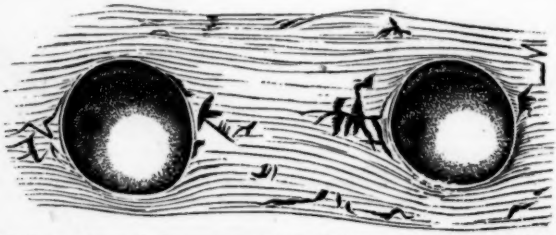

FIG. 5.—TWO "GLASS-PEARLY" ORGANS FROM THE SIDE OF *Scopelus Humboldtii*, moderately magnified.

oped, one of which leads through the pseudo-electric organ of the *Gymnarchus niloticus* and the disk-like organs of the Scopelids to the real electric organs, while the other series includes the eye-like organs of the sternoptychids; an apparatus which is also represented in the larvæ of salamanders.

The appearance of this phenomenon in the amphibia, frequently observed as they approach the fish type, should point to some definite connection between the activity of those organs and water-life; but the nature of this activity, whether electricity is developed by it or not, is still veiled in complete darkness.

These organs have been regarded by many as luminous organs. A single glance shows that the body and lateral walls of the disk shine with a silvery and golden luster, but not different from that of the background of a fish's eye when viewed before a screen. More striking is the appearance in the case of the larger organs of the head in certain species, which are pre-eminently marked by it as a luminous apparatus. But, if the sole object of the apparatus were the collection and reflection of the light which fell upon the fish, its complicated structure in other respects, and its innervation, would be superfluous and still more incapable of explanation. We have, however, an observation that seems to show that these organs not only collect light, but are also really phosphorescent. The distinguished naturalist of the Challenger Expedition, Willemoes-Suhm, now deceased, saw Scopelius phosphorescent in the night, of which he says: "One of them hung in the net like a shining star as it came out of the darkness. Possibly the seat of the light is in the peculiar side organs, and it may be that this phosphorescence is the only source of light in the great depths of the sea." The thought that in the dark abysses of the deep sea every animal carries its lantern as the miner carries his lamp on his head, is a very fascinating one; and, indeed, Herr Willemoes-Suhm observed several other fishes that were provided on the smooth head and on the head-beard with "a remarkably large sense-organ." Valenciennes has also remarked of the genus *Hemiramphus* that it bears a strongly glittering phosphorescent pustule on the tip of its tail. Although the majority of these animals have never been observed in a living condition, we might easily agree to the opinion that the or-

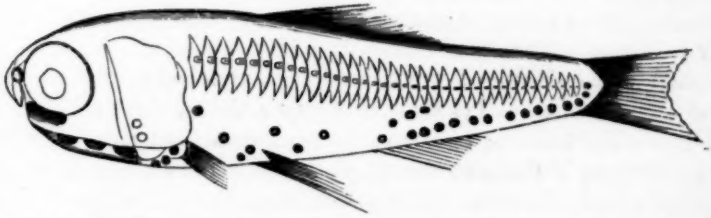

FIG. 6.—*Scopelus Rafinesquii*, twice the natural size. Two luminous organs in the ocular region.

gans of all three categories serve as a more or less perfect illuminating apparatus; and, if we compare Professor Leydig's sections of them, this opinion, which is only very apparent at the first view, becomes extremely probable. Especially does the section of the eye-like organ of *Argyropelecus* and *Ichthyococcus* resemble the illuminating parts of a projection-apparatus. If we conceive the granular spot in the center, into which the nerves enter, as the source of light standing in the middle of the apparatus, there are likewise behind this the concave reflector, and in front of it the diaphragm through which the concentrated cone of rays is thrown outward under a strong refraction.

In the pearl-like organs, also, if we have understood Professor Leydig's description aright, a curved, refracting body seems to lie on the side of the organ that is turned outward. We should thus, if our presumption is confirmed, have here not a simple illuminating organ, but a complete optical illuminating apparatus in different degrees of perfection, throwing out in an extremely concentrated condition, by means of a concave mirror and lenses, the phosphorescent light generated within it; and the fishes under consideration would be fully equipped with a series of little, button-shaped illuminating apparatuses.

I may assert here that there is nothing hazardous in this idea. As Professor Leydig has maintained, the "eye-like," and the "pearl-like," and the really luminous organs, are of thoroughly homologous structure, and we know of the latter, the only ones that have been observed in a living animal, that they emit a star-clear light. If, now, Nature has provided us with a most wonderful *camera-obscura* in our eyes,

FIG. 7.—CAUDAL EXTREMITY OF *Scopelus Humboldtii*, with "glass-pearly" organs, and a large pearl-spot.

why may she not also have produced a much simpler light-house lantern—provided, of course, that such an apparatus could be useful to the animal? I have already had something to say concerning the uses of their luminous apparatus to different animals ("Kosmos," vol. vii, p. 479), and have endeavored to show that their principal service is probably as a means of exciting fear. At any rate, the opinion may be given up that the light diffused by the deep-sea animals is a means of clearing up the purple darkness below, or, as some have thought, of producing the diversified hues of the deep-sea animals. Animals living in the dark do not require light for their existence, as is demonstrated by the numerous blind cave-animals. The opinion, also, that the luminous fish make their prey in any way visible by means of the organs subsidiary to their eyes could not in any degree help to account for the existence of luminous apparatus on the lower part of their bodies, for their eyes would not be able to see what those organs lighten up; but such organs might very well make the animal more visible from a distance, and might thereby serve a similar purpose with the protective colors of the animals of the upper world, especially if the appearance were associated with a disagreeable taste or smell. Only in some such manner as this can we account for the luminous organs, for example, of a crustacean that was brought up by the Challenger Expedi-

tion from a depth of nineteen hundred fathoms, and which was totally blind.

Professor Leydig remarks upon this point that the luminosity is, for the most part, only a subsidiary shining dependent on the secretion of a fatty body, and that the significance of the formations as electrical and pseudo-electrical organs is not altered on that account. We might also remark on this subject that, according to Kölliker's observations, the luminosity of many animals is under the influence of the will, so that the innervation of the phosphorescent organ no longer seems superfluous; and that, according to Jousset de Bellesme, glow-worms cease to shine as soon as their principal ganglion is removed. Moreover, according to Bellesme's observations, the glow may be produced by electrical as well as by nervous excitation. At all events, the hypothesis which I have submitted appears to me to be worthy of a searching examination.—*Translated from Kosmos.*

THE APPOINTMENT OF COLLEGE OFFICERS.

By F. W. CLARKE.

THERE are to-day in the United States over four hundred institutions claiming the title of college or university. Some of them are really, a few confessedly, only high-schools or academies; and between these and the highest there is every diversity of grade. In them there are over four hundred "presidents," "principals," "chancellors," or whatever the heads of the institutions may be called, and some thousands of professors or teachers. This great body of men and women is continually changing; yearly there are deaths, removals, and resignations; yearly there are a multitude of new appointments. The purpose of this essay is to inquire how such appointments are made, and how they ought to be made; what considerations do govern, and what should govern, the selection of college officers.

At a casual glance it would seem as if little could be said upon the subject; of course appointments are made by regular boards of trustees, and of course each appointment is determined by the peculiar fitness of the successful candidate for the position he is to occupy. Such is the theory, but the application thereof may be exceedingly elastic. Strange standards of fitness are frequently adopted; and appointments to responsible positions are often made upon principles which would be recognized in no other kind of business except the trade of partisan politics. In political life an efficient officer may be displaced for mere party reasons, and supplanted by some one altogether his inferior. In the college world, slight shades of difference in theological belief are at times similarly potent.

The qualifications demanded of a college president are different in different places. In some institutions the head is purely an executive officer, with no teaching to do; in others he must fill a professor's chair also. On the one hand, a man of general scholarship, breadth of view, and executive ability is called for; on the other, special familiarity with some particular branch of learning must be added to the requirements. To find all these qualifications united in one individual is by no means easy. A man of one ability is easily found at any time; but men of many abilities, at once both versatile and thorough, are scarce. In any case, the college president, to be a successful manager, must have tact; he must have executive capacity and force; he must be business-like in his methods, he must command the confidence and respect of trustees, teachers, students, alumni, and of the community in which he lives; he must be a good judge of men; and he must have the training which only experience can give. Failing in any one of these qualifications he is liable to fail altogether, for the strength of the whole chain is but that of its weakest link. He must have public confidence, in order to attract public support; he must be in harmony with the faculty, or things will go at loose ends; if the students distrust him, discipline can not be maintained. When vacancies occur in the teaching force, he will have great influence in filling them; hence he must be familiar with scholarship in its various phases, and able to decide upon the relative merits of different candidates. Finally, he must be thoroughly acquainted with college routine, clear in his views concerning courses of study and methods of instruction, up in all matters relating to marks, examinations, discipline, and the like. He should have high ideals, and at the same time be neither a *doctrinaire* nor a dreamer.

The fact that most of the older American colleges were founded with religious ends in view has had much to do in determining the appointment of college presidents. Plainly, if the chief function of the schools is to train clergymen, they should be controlled by clergymen; and so they have been controlled almost universally. If a Baptist college needs a president, some Baptist clergyman is chosen; a Presbyterian college puts a Presbyterian minister at its head, and so on. That this state of affairs has naturally come about no one can deny, but whether it is any longer a legitimate condition is questionable. The functions of the college are broader than they were a century ago; it no longer aims chiefly to feed the ministry, but seeks rather to send cultivated men and women into all walks of life. Hence, although a minister may be an efficient college president, he should not be appointed because he is a minister, but for other reasons distinctly. Just here an example may have value. A few years ago a popular clergyman was elected president of a well-known college. Within a year his popularity was gone, and students, professors, and trustees were alike dissatisfied. The reason was simple. The new head was a

clergyman only—not an educator. As head, being a man of energy, he meddled with things which he had not learned to understand, harassed the pupils, doubtless with the best of intentions, attempted to carry out impracticable measures, and made trouble generally. Fortunately, he was a man of some tact, and able to learn wisdom by experience, so that after a while order was restored, and at last he regained popularity and confidence. But he learned his new trade at the expense of the institution, which suffered during the period of his tutelage. Would it not have been better if he had begun as a tutor, then risen to the rank of professor, and finally been promoted to the presidency after he had shown his fitness? In brief, is it not safe to say in general terms that no man because of success in one profession should at once be intrusted with the highest place in another? The loftiest positions in any line, political, educational, or what not, should be earned by faithful service and proved capacity in the lower grades. There may be exceptional cases, but they are so rare as to count for nothing in establishing the general principle. Special knowledge, training, and experience are demanded of a college president just as much as of a bank cashier, an army officer, or the captain of a ship; and rules like those which govern the latter classes of appointments should hold good in the educational profession also.

Since the duties of a professor are more easily defined than those of a college president, the rules governing his appointment ought to be correspondingly simpler. In general he is to teach a single subject or groups of allied subjects, and should therefore be chosen for special knowledge of the branches indicated. If he is to fill the chair of Latin, he must necessarily be selected because of his scholarship in Latin; if he is to teach mathematics, he must be a mathematician; and so on. Furthermore, good character and efficiency are essential. It would seem as if there could be no doubt upon these points, as if no argument about them were possible; and yet, as a matter of fact, plain as they are, they are frequently ignored. Favoritism, nepotism, and sectarianism often outweigh all other considerations even in the college world; and men of no genuine scholarship secure appointments over candidates whose real credentials are vastly higher. The son of a college president may be appointed to teach some subject in which he has never been properly trained; an unsuccessful clergyman may be provided for by assignment to a professor's chair; and such things, far from being mere abstract possibilities, do actually occur. Still other absurdities are continually being perpetrated. The writer has known of a case in which a teacher was invited to take any chair he chose in a certain Western college; and of another instance in which an applicant for a professorship offered to accept any department that might be offered to him. Professors have been known to begin their own studies in the line of their professorships after they had been elected; and some years ago the trustees of one college passed a rule

to the effect that any member of the faculty could be called upon to teach any subject, under penalty of dismissal if he refused. This ignorance puts a premium upon intellectual dishonesty. It needs no argument to show that all such cases result in inefficiency and superficiality; the colleges represented by them are shunned by competent men, they suffer in reputation, and at last they dwindle into mere local academies. Fortunately, the law of natural selection holds good among institutions as among animals, and in the long run only the fittest flourish and survive.

But all vices are not great vices, and small crimes against college morality are committed even by old and famous institutions. For example, a certain Professor of Natural History has been wittily described as "a good theologian, slightly tinctured with zoölogy"; his appointment having been secured by raising false issues of the ultra-sectarian kind. It is hardly necessary to add that the highly respectable college in which he teaches is not recognized as a shining center of zoölogical research. In the same institution a teacher of mathematics was to be appointed; and an enthusiastic friend praised the mathematical ability of a leading candidate. "No matter about his mathematics," said one of the authorities, "we want to know if he is a man of good moral character." The remark was suggestive. Of course, moral character was essential, and to be scrupulously considered, but not above other qualifications equally important. Character and competency need both to be regarded; since a man may be a model of purity, and at the same time incapable of teaching even the alphabet. Candidates for professorships are often sharply catechised. "What church do you go to?" "What are your views upon such and such doctrines?" These questions are almost invariably asked. "Are you a professor of religion?" said a college trustee to a young candidate for a position. "No, sir, I am a professor of chemistry," was the reply, and rejection followed. Curiously enough, the college represented by this instance was not a sectarian school, but a State institution, founded upon the congressional land-grant of 1862. From such-like impertinent questions some of the ablest scholars in America have suffered. Pure character, unblemished reputation, high scholarship, and great achievements, are not sufficient for answers. Only a rigid conformity to certain dogmas can render the candidate's calling and election sure. Hypocrisy may succeed where real merit would avail but little.

Since a tutorship is the natural stepping-stone to a professorship, tutors should be chosen for qualifications essentially the same as those which are demanded of professors. There are now available a multitude of competent young men, who are ambitious to win professorships, and who, with that aim in view, have devoted years of laborious study to special preparation for special teaching. Some are chemists, who have pursued original investigations at Berlin, Leipsic, Bonn,

Harvard, or Baltimore; others have studied philology, under the foremost German masters; still others have become thorough biologists, students of history and philosophy, or mathematicians. From among these the ranks of tutors should be filled, and legitimate promotion, in due time, ought to follow.

At some colleges, Harvard for example, the policy above indicated is followed. If a tutor in Greek is needed, some young man who has distinguished himself in Greek is chosen; and, upon the hypothesis that he intends to make a life-work of classical study, he is given every advantage to distinguish himself still further. In some other institutions, however, a different plan is adopted. At Yale, for instance, tutors are often, if not always, appointed in a sort of general way, without particular reference to special studies, the subject to be taught by each being settled afterward. In consequence, a Yale tutor, whose real specialty is mathematics, may be obliged to teach only Latin; while another, whose bias is purely classical, may have to struggle with pupils in trigonometry. Doubtless these evils are greater in appearance than in reality; probably in most cases matters adjust themselves in a more rational way; still, in some instances, the mischief is really done. Such a state of affairs ought not to be even possible. It is sometimes urged, in extenuation, that every young man who has graduated creditably ought to be able to teach others whatever he has himself learned; and, in a measure, this is true. But a fellow may have studied mathematics only as a matter of routine, getting none of its real spirit, and putting no enthusiasm nor vigor into his work. Doubtless he can carry others through the same routine afterward, hearing recitations from a text-book, and recognizing such mistakes as may be made; but "teaching" of this kind is hardly worthy of the name. Every college teacher, whether professor or tutor, ought to *feel* the subject which he teaches; he should be able to rouse the interest of his pupils, to stimulate thought among them, to encourage the bright ones forward, and to remove difficulties from the paths of those who lag behind. Such work can be done only by special scholars, who have taken up their life-tasks as a labor of love, and who are brimful of earnestness and enthusiasm. With the lower college classes this scholarly vigor is especially needed. The pupils must be started aright at the very beginning, for, if their interest is not awakened then, there is great danger that it may continue sleeping always. But in no part of a college course should mere perfunctory instruction be tolerated. A man may be a teaching machine, and yet fall very far short of being a teacher.

Now, having discussed the reasons governing college appointments, we may fitly consider the methods by which the appointments should be made. Suppose that there are several competent candidates for a given position; how shall one be selected, and by whom? Technically, there can be but one answer to this question, namely, that the

trustees of the college must choose ; but practically this answer does not fairly cover the case. The average board of trustees consists not of special scholars, but of men in active life—merchants, manufacturers, lawyers, doctors, and the like ; with oftentimes a liberal sprinkling of clergymen thrown in. It may be that not one of them has any special knowledge of the branch to be taught by the proposed appointee, or any adequate means of judging independently as to the relative fitness of the candidates. In some instances, too, they meet but once a year, namely, at commencement time ; and in such cases a decision must be reached in advance of the meeting. Clearly, then, they must act upon recommendations ; and the practical question is, Whose recommendations shall carry the most weight ?

To this question a great variety of answers are possible ; as may be shown by citing three common modes of procedure : First, an election may be carried by personal lobbying ; the candidates and their friends seeking out individual trustees, and, by all sorts of arguments, relevant and irrelevant, securing pledges of support. This process is objectionable enough in politics, but it is tenfold worse in educational affairs. Secondly, the president of the college may decide between the candidates, and make a recommendation upon his own responsibility—a method which is perhaps the one most generally followed. Thirdly, the faculty as such may be officially consulted, and their nominee given the appointment. Ignoring the first plan as unworthy of consideration, let us examine carefully the other two.

The efficiency of the second mode of appointment naturally depends upon the character, tact, and temperament of the college president who attempts to carry it out ; and it may lead either to good results or to mischief. A wise president, having an appointment to recommend, will scrupulously consider all the interested parties. Having ascertained all the essential facts concerning the available candidates, and being satisfied as to their antecedents and ability, he will consult with his associates upon the faculty, especially with those most interested in the appointment to be made, and in his final decision he will give due weight to their advice and wishes. Theoretically, this method is simple enough, but in its practical application it is often attended by serious difficulties. Sometimes a faculty is split into cliques, and then the president must either make an independent decision, or else take sides with one faction as against another. Such dilemmas are common, and bring great uneasiness to their victims. A new president may find an old faculty half buried in a rut from which it can be lifted only by fresh and vigorous men ; he may be embarrassed by alumni, who expect appointments in preference to outsiders ; there may be tutors who will growl and grumble if not promoted in accordance with their own notions as to their deserts. Whichever way he turns he is liable to create dissatisfaction and heart-burning ; the unsuccessful candidates and their friends all abuse him for favoritism

and incompetency; in short, all the worst features of personality may be introduced into a contest which above all others ought to be unaffected by personal considerations. Many a college war has sprung from conflicts over appointments; and only an exceptionally strong president can long hold out against the difficulties which such contests are apt to raise against him. With but few men is the method of personal appointments successful; with many it leads to inharmony and overthrow.

The third method of appointment, namely, upon recommendation from the faculty, seems to be the most satisfactory of all. Of course, it is not absolutely perfect, for it may give rise to dissensions; but, on the whole, it leads to better results than any other. The unsuccessful aspirants for position can not blame and harass one individual, as when the power of appointment is practically vested in the president alone, for the annoying responsibility is divided among several persons; neither can favoritism be urged as the reason for any particular choice. Furthermore, since any good faculty consists of a number of men actively engaged in scholarly work, its judgment as a body concerning the fitness of candidates is more likely to be accurate than the opinion either of a president or of a board of trustees who can not be expected to give more than superficial attention to the matter. The members of a faculty know of their own knowledge what standing a candidate has as an educator, what work he has done, and what he is probably capable of doing; and this knowledge, which frequently involves long personal acquaintance with the aspirant, is worth much more than any information derived from mere formal letters of recommendation or from hearsay. Whoever is recommended by them will be a safe person to appoint, and will be likely to work in harmony with his colleagues. They, on the one hand, calling a man to a vacant chair, will be gratified by his acceptance; while he, on the other side, will feel grateful to them for their consideration. It is well known that this method of appointment is in vogue at the Sheffield Scientific School; and it is said that no professor has been called to that institution except upon the *unanimous* recommendation of the faculty. The natural result is a harmonious and efficient body of teachers, and an exceptionally strong school.

Inasmuch as this third method of appointment presupposes a faculty already in existence, it can not of course apply to those schools which are in process of organization. In such cases it is best for the trustees to select a strong and competent man for president in whom they can have full confidence, and give him almost autocratic powers. Let him choose the first faculty, drawing about him such teachers as will work in unison with him and with each other; and then refer all subsequent appointments to that body. Of course, in no case should a board of trustees surrender its own authority, but the recommendations of a faculty should be ignored only for the most substantial of reasons. Be-

tween faculty and trustees there ought to be perfect concert of action; when either body distrusts the other, mischief is sure to happen. The method by which teachers are appointed should be a matter of usage and policy, not of prescribed rule; and the method above laid down seems to be the safest in the long run. A faculty can not maintain the highest efficiency unless it is thoroughly harmonious; any jar or friction in it leads to dissatisfactions which quickly spread to the students, and the result is disastrous to all the parties concerned.

SIR CHARLES BELL AND PHYSIOLOGICAL EXPERIMENTATION.

By Dr. WILLIAM B. CARPENTER.

IT has been repeatedly urged, by the opponents of physiological experimentation, that Sir Charles Bell in his later life declared that his physiological discoveries had been really made by anatomy only, and that he had only made experiments for the satisfaction of others; and a quotation to this effect has been lately brought prominently forward by Mrs. Dr. A. Kingsford, in order to set in the most unfavorable light what she characterizes as the needless, fruitless, and barbarous experiments of Magendie on the same subject.

As it is probable that the vivisection question will be again brought before Parliament, I think it important that the public should be informed of the *real* history of the discoveries with which Sir Charles Bell is commonly credited; that history having been most erroneously narrated by his brother-in-law, Mr. A. Shaw* (who may be presumed to have written with Bell's sanction and authority), and its errors, though fully exposed at the time† (during Bell's life), having been repeated and even exaggerated by the most recent of his biographers.‡

The great discovery ordinarily attributed to Sir Charles Bell is that of the distinctness of the *motor* and *sensory* nerve-fibers; as shown by the separate existence of motor and sensory endowments, (1) in the anterior and posterior *roots* of the spinal nerves, in whose *trunks* these two orders of fibers are bound up together; and (2) in certain nerves of the head, some of which are motor only, while others are sensory only. These doctrines, according to Mr. A. Shaw, had been conceived as far back as 1809; and were then embodied in a tract which Bell printed for private distribution among his friends,#

* "Narrative of the Discoveries of Sir Charles Bell in the Nervous System" (1839).

† "British and Foreign Medical Review," January, 1840.

‡ "Encyclopædia Britannica," vol. iii (1875).

Sir Charles Bell himself fixed the date as 1811.

under the title "Idea of a New Anatomy of the Brain." In support of this statement Mr. Shaw cited certain passages from Bell's very scarce tract, which, read in the light of subsequent events, seemed an adequate justification of it. But, unluckily for the credit of both, a copy of the tract had found its way into the possession of a certain Mr. Alexander Walker, who had claims of his own to advance; and he reprinted it in full in a thin volume (now before me) published anonymously in 1839, under the title of "Documents and Dates of Modern Discoveries in the Nervous System."

I well remember the sensation which was produced at the time, among those who took an interest in the subject, by this publication; from which it plainly appeared that the fundamental conception enunciated in this "Idea" had gone no further than this—"that the nerves of sense, the nerves of motion, and the vital nerves, are distinct throughout their whole course, though they seem sometimes united in one bundle; and that they depend for their attributes on the organs of the brain to which they are severally attached"; while, in carrying out this conception, Bell, misled by his anatomy, had *gone altogether wrong*.

This doctrine was by no means new. It had been known from a very early period that our limbs can only feel or move (I use these words in their *ordinary* sense) by virtue of the nerve-trunks which connect their skin and muscles with the spinal cord, and through it with the brain. And although, when a limb is paralyzed, it is usually deprived at the same time of feeling and of motion, yet as cases were occasionally observed in which motion was lost without feeling, or (more rarely) feeling was lost without motion, the idea arose that two distinct sets of fibers may be bound up in the same trunks; one for feeling and the other for motion—or, as we should now express it more scientifically, one set conducting impressions made on the sensory surfaces toward the central *sensorium*, while the other transmits nerve-force from the *motor* centers of the nervous system to the muscles which it stimulates to contraction. This idea found distinct expression in the writings of certain ancient medical authors; and cropped up from time to time in modern medical literature, some writers approving it, while others dissented from it. And it was formally advanced in 1809 by Mr. Alexander Walker, who, in a paper entitled "New Anatomy and Physiology of the Brain in Particular, and of the Nervous System in General," published in the "Archives of Universal Science" for July in that year, argued that "medullary action" (or, as we should now say, a nerve-current) "commences in the organs of sense; passes, in a general manner, to the spinal marrow, by the *anterior* fasciculi of the spinal nerves, which are, therefore, *nerves of sensation*, and ascends through the anterior columns of the spinal marrow, to the hemispheres of the cerebrum," in which he located the *sensorium commune*. Thence he traced his "medullary action"

downward and backward into the cerebellum, which he supposed to be the center of *volition;* from this "it descends through the posterior columns of the spinal marrow, and expands through the *posterior* fasciculi of all the nerves, which are, therefore, the nerves of *volition*, toward the muscular system."

Thus, then, it is clearly Mr. Alexander Walker who must be credited with the first promulgation of the *idea* of the functional distinctness of the anterior and posterior roots of the spinal nerves, in virtue of what he supposed to be their connections with the cerebrum and the cerebellum respectively: but, working out this idea under a wrong conception of the relative functions of the two brain-centers, he was led to regard the *anterior* roots as *sensory*, and the *posterior* as *motor;* and, as he neither submitted nor proposed to submit this erroneous doctrine to the test of experiment, it fell unheeded to the ground.

Now, those who only know the history of Bell's work either directly or indirectly through Mr. A. Shaw's first account of it, will be considerably surprised to learn that (whether or not he was acquainted with Walker's speculations) he pursued, in the first instance, precisely the same anatomical track; and that, through his having followed this under the guidance of another wrong preconception as to the functions of the cerebellum (which had not at that date been elucidated by experiment), the physiological conclusion at which he arrived was even further from the truth than that of his predecessor.

A distinguished Edinburgh professor of the last century, Dr. Robert Whytt, who had studied with great care what he termed the "vital and involuntary motions" of the body, had argued with considerable ingenuity that, while the *cerebrum* is the center of sensation and the originator of voluntary motion, the *cerebellum* is the organ of such "vital and involuntary motions" as the action of the heart and the muscular walls of the alimentary canal, together with the movements of respiration. Now, Bell, brought up in the Edinburgh school, and commencing his investigations under the influence of this prepossession, was led by it in an entirely wrong direction; for the whole argument of his "Idea" is to the effect that the *anterior* roots of the spinal nerves minister *both to sensation and voluntary motion*, in virtue of their connection with the cerebrum, while the *posterior* roots "govern the operation of the viscera necessary to the continuance of life," in virtue of their connection with the cerebellum. He did institute experiments, indeed, both on the columns of the spinal cord and on the roots of the spinal nerves; but, under the influence of his anatomical preconception, he entirely missed the true meaning of their results, and deemed them to be confirmatory of his erroneous views:

"Experiment I.—I opened the spine, and pricked and injured the posterior filaments of the nerves; no motion of the muscles followed.

I then touched the anterior division; immediately the parts were convulsed."

"EXPERIMENT II.—I now destroyed the posterior part of the spinal marrow by the point of a needle; no convulsive movement followed. I injured the anterior part, and the animal was convulsed."

The experiments thus narrated by Bell in a letter to his brother, dated March 2, 1810, have been cited as proving that he had thus early attributed motor functions to the anterior roots, and sensory to the posterior. But the inference which he himself drew from them at the time was altogether different:

"It is almost superfluous to say that the part of the spinal marrow having sensibility [i. e., the anterior column] comes from the cerebrum; the *posterior and insensible part* belongs to the cerebellum."

Thus, although on the track of a great physiological discovery, Bell allowed himself to be completely diverted from it by his anatomical preconception. Of the *true* functional relations of the two sets of nerve-roots, there is *not the remotest hint* in this "Idea."

None the less, however, do I recognize in it what (to my mind) constitutes the *real* basis of Bell's claim to the elucidation of the meaning of the double origin of the spinal nerves. "Considering," he said, "that the spinal nerves have a double root, and being of opinion that the properties of the nerves are derived from their connections with the parts of the brain, I thought that I had an opportunity *of putting my opinion to the test of experiment, and of proving at the same time that nerves of different endowments were in the same cord and held together by the same sheath.*" This was, unquestionably, one of the most fertile suggestions that the insight of a man of genius has ever put forth for the guidance of physiological inquiry; and, even if Bell had never himself pursued it further, he would clearly be entitled to a very large share of any discoveries that others might make by working upon it. It seems, however, as if the unsatisfactory character of the results he obtained and his dislike to experimentation upon living animals turned his thoughts in a different direction; and he applied himself for some years to the study of the nerves of the face, on the peculiarities of whose anatomical distribution he seems to have long pondered, with the idea that these might furnish him with the key of which he was in search.

Bell, as is well known, had considerable artistic ability; and one of the earliest of his publications was his very valuable "Anatomy of Expression," in which he pointed out how close is the relation between many of the muscular movements by which the emotions are expressed and those concerned in respiration. Still, as it would seem, under the "dominant idea" of a special set of nerves for the "vital and involuntary motions," he assigned this special motor function to the *seventh* pair, which arises by a single root, and supplies the muscles of the face generally; while he supposed the *fifth* pair, which arises (like

the spinal nerves) by a double root, to be the nerve of ordinary (or voluntary) motion for the muscles of the face generally, as well as of sensation for its sensory surfaces. The analogy of the fifth pair to the spinal nerves (which was no new idea) seemed to him to be further indicated by the existence of a "ganglion" upon its larger root, corresponding with that which is seen on the posterior roots of the spinal nerves. Following up this train of reasoning, he *instituted experiments* with the view of determining what function the fifth pair *had* in virtue of its double root, which the seventh pair *had not*. And as he found that division of the seventh pair, while partially paralyzing the muscles of the face, did not in any perceptible degree impair its sensibility, while section of either of the three divisions of the fifth pair destroys the sensibility of the part of the face it supplies, he came to the conclusion that the sensory endowments of the fifth pair are due to its possession of a double root; a conclusion which he strengthened by the consideration that the third, fourth, and sixth nerves—which, being distributed exclusively to the muscles of the eyeball, can not be supposed to have any but motor endowments—all arise by single roots.

In this way, Bell was led to assign to the two roots of the *spinal* nerves the same double function which he attributed to the two roots of the fifth pair of nerves of the head; and thence to assign the sensory function to the posterior roots, because, like the second root of the fifth, they bore ganglia before uniting with the motor roots.* Now, to say that Bell, by this train of reasoning, *discovered* the motor and sensory functions of the anterior and posterior roots of the spinal nerves, is utterly preposterous. He had not even truly determined (as the event proved) the true functions of the fifth and seventh nerves of the head. And the extension of his conclusions regarding the double roots of the fifth pair, to the spinal nerves generally, had rather the character of a happy guess than of a logical sequence. No scientific physiologist at the present time would think himself justified in putting forward such an extension as more than a *suggestion*, to be confirmed or negatived by experimental evidence. And let it not be forgotten, moreover, that it was *experiment alone* which afforded Bell any reason whatever for attributing a sensory function to the gangliated root of the fifth pair; and that, without this basis, the question of the spinal nerves remained exactly in the condition in which he had taken it up.

It is, indeed, not a little curious that in the two memoirs (1821 and 1822) in which Bell presented to the Royal Society the results of

* It is a significant indication of the chaotic ignorance which prevailed on this subject "sixty years since," that, as Bell himself informs us, he found himself met, when first groping at the notion of the sensory endowments of the posterior roots of the spinal nerves, by the current doctrine that the function of the ganglia is "to cut off sensation," i. e., to allow these nerves to minister to the "vital and involuntary motions," without our being made conscious either of those movements or of the impressions which excite them.

his investigations into the fifth and seventh nerves of the head, the present doctrine of the spinal nerves is *nowhere explicitly stated.* These memoirs can scarcely, indeed, be read in any other sense; and "A Manual of Anatomy," published by Mr. John Shaw (another brother-in-law) in 1821, contains a tolerably clear intimation of it. Moreover, Mr. J. Shaw, having visited Paris in 1821, and having repeated to Magendie the experiments on the fifth and seventh nerves which he had made with Sir C. Bell, further pointed out to him (as appears from Magendie's own narration) * the analogy of the fifth to the spinal nerves, and attributed to the double roots of these "regular" nerves this double function of motion and sensation.

It was at this point that Magendie took up the experimental inquiry, both as to the roots of the spinal nerves and the functions of the fifth and seventh nerves of the head; and it will be convenient to dispose of the latter in the first instance. He showed that the second of the three divisions of the *fifth* pair is a nerve of sensation only; so that the part of the face which it supplies (between the eyes and the upper lip) depends for its motor action on the *seventh* pair, which he regarded as the *ordinary motor nerve* of the face, ministering to its *voluntary* movements, as well as to those of expression and respiration. These corrections (which were confirmed by other experimenters) were not only accepted by Sir C. Bell, but were *appropriated by him as his own;* the reprints of the two memoirs just referred to being altered in successive editions of his "Nervous System of the Human Body," by omission, addition, and variation, not only without any acknowledgment of the source of the correction, but without the least intimation of a change. It is clear, therefore, that although he shrank from making experiments himself, he was ready enough to profit by those of others.

On testing experimentally Bell's idea of the functions of the anterior and posterior roots of the spinal nerves, and varying his experiments in every way he could think of, Magendie was only able to arrive at this general conclusion—that the anterior roots are *more especially motor,* and the posterior *more especially sensory.* For he could not get over the fact that irritation of the anterior roots in the living animal called forth signs of pain, and that irritation of the posterior roots called forth movements. The repetition of the same experiments by others gave no more conclusive results; until, in 1831, Johann Müller (afterward the celebrated Berlin professor) was able, by a very carefully devised method of experimentation upon frogs, to show that, for these animals at least, Bell's doctrine was correct. And it was by the extension of the same method to warm-blooded animals, and by the light of the new ideas then dawning † as to the "reflex

* "Journal de Physiologie," October, 1821.

† The very clear ideas long before promulgated by Prochaska on this point had been entirely forgotten.

function" of the spinal cord (which up to this time had been generally looked on as a bundle of nerves), that the truth of Bell's doctrine came at last to be fully established. For the *movements* called forth by irritation of the *posterior* roots were found to be due, not to the direct transmission of motor impulses from them to the muscles, but to the transmission of a motor nerve-current through the anterior roots, in response to the stimulation given to the spinal cord itself by the irritation of the posterior; while, on the other hand, it was made clear that the indications of *pain* given when the *anterior* roots are irritated, are due to the presence, in those roots, of sensory filaments derived from the posterior, which pass inward at the point of junction between the two. But for the well-devised and carefully executed experiments by which these difficulties were cleared up, the whole matter would have remained in the state of uncertainty in which I well remember it to have been, when I first entered on the study of the subject, previously to Müller's experiments.

Having myself been afterward Sir Charles Bell's pupil (in surgery) both in London and Edinburgh, I can testify from personal knowledge that he himself never admitted that his discoveries needed any confirmation whatever; but was always strong in the conviction, not only that he had himself given all needful evidence of them, but that nothing more remained to be done in the physiology of the nervous system. It is not a little significant of his attitude of mind on this subject, that he used to declare his complete inability to understand "what Marshall Hall was driving at"; the doctrine of reflex action independently of sensation being altogether "beyond his comprehension." As this last doctrine, which forms the basis of modern neurology, is one which anatomy could scarcely even suggest, and which nothing but experiment can demonstrate, I hope that Sir C. Bell's opinion of the all-sufficiency of the study of anatomy for the advancement of physiological science may henceforth be appreciated at its true worthlessness. For I have shown, *first*, that Sir Charles Bell, trusting to anatomy for his guidance, *went altogether wrong* in the first instance; *secondly*, that it was by *experiment* on the nerves of the face that he was led into the *right* track; *thirdly*, that in regard to these, through placing too much trust in his anatomical preconceptions, and insufficiently testing them by further experiments, he was led into mistakes which were only corrected by the experiments of Magendie; and, *fourthly*, that the most important discovery with which he is usually credited—that of the motor and sensory functions of the anterior and posterior roots of the spinal nerves respectively—was only *established* in the true scientific sense by the experiments of others working on his lines. Those experiments might have issued, for any real proof ever given by Bell to the contrary, in establishing some other doctrine of the spinal nerve-roots than that to which he had been led by his study of the nerves of the face—such, for

example, as that of Alexander Walker, or that of his own first "Idea."

These assertions are not now made for the first time, with the view (as might be urged) of lowering Sir Charles Bell's credit, and thereby weakening the force of the testimony borne by him in regard to the uselessness of experimentation as a means of physiological discovery. Forty-two years ago, the history I have now sketched (which was then a matter of contemporary knowledge) was told in detail in the leading medical "Quarterly"; the misrepresentations of Mr. A. Shaw as to Sir C. Bell's "Idea" of 1811 were fully exposed; and Bell himself was distinctly charged with having altered what professed to be exact reprints of his papers in the "Philosophical Transactions," in order to make them square with the corrections supplied by the experiments of Magendie. To those charges, so far as I am aware, *no reply was ever made*, either by Mr. A. Shaw or Sir C. Bell; but a new and more correct history, including a reprint of Bell's "Idea," was given by Mr. A. Shaw nearly thirty years later in the "Journal of Anatomy and Physiology" (vol. iii, 1869). Further, in Professor Vulpian's "Leçons sur la Physiologie du Système Nerveux" (Paris, 1866), the history is narrated in terms almost identical with my own, omitting only the reference I have supplied to Magendie's first knowledge of Bell's views, but inserting several of the altered passages in Bell's papers. And, finally, the venerable Professor Milne-Edwards, in his admirable "Leçons sur la Physiologie et l'Anatomie Comparée" (tome xi, pp. 361, 362), has given a most true and just appreciation of the respective shares which Bell and Magendie had in this great discovery.

I have never admitted the truth of the well-worn adage, "A little knowledge is a dangerous thing"; because every one who studies any subject whatever *must* begin with "a little knowledge," and only by its possession can know where and how to obtain more.

But "a little knowledge" *is* dangerous when it leads its possessor to imagine that he (or she) knows *all* about the subject; and is *doubly* dangerous when it is taught as the whole truth to others. And this is exactly what Mrs. Dr. A. Kingsford has done, in her desire to excite a prejudice against physiological experimentation; fastening eagerly upon Sir Charles Bell's depreciation of it, without taking any trouble to ascertain historically what that depreciation is worth.—*Fortnightly Review.*

THE ZUÑI SOCIAL, MYTHIC, AND RELIGIOUS SYSTEMS.*

By F. H. CUSHING

GENTLEMEN OF THE NATIONAL ACADEMY OF SCIENCES—LADIES AND GENTLEMEN: Let me at once present my Indian friends. And now let me introduce some remarks on the mythology and religion of the people whom they represent, the Zuñi Indians of Western New Mexico, the largest of the Pueblo nations, the lingering remnants of a vast culture which gave rise to the cliff and *mesa* ruins of the far Southwest, by a few words designed rather to define my own position than to illustrate my subject.

The student of the natural history of mankind finds his most difficult subject in the mythology of the lower peoples. Even our own mythology, including our theisms and superstitions, is hard to understand, yet ours is, thanks to just such bodies as the one which I have the honor to address to-day, the simplest of all mythologies, because its range of superstition is circumscribed by that of definite knowledge, its theism simplified in proportion to the extent of material philosophy.

Perhaps first among the causes of our difficulty is the fact that all mythology deals with those forces and things in nature which are beyond our comprehension; that it ends not here, but attempts to explain the origin of things in themselves incomprehensible. In proportion, then, to the lack of definite knowledge in any people, its mythology becomes more complicated and less readily understood. To the same intellectual germ in humanity which quickens the philosophy of the nineteenth century may we look for the cause of the origin and growth of mythology. And thus it happens that we find the scientist of our own places and times and the Zuñi Indian laboring hand in hand in the same field, both trying to explain the phenomena of nature and their existence, the one by metaphysical the other by physical research; the one by building up, the other by tearing down, mythology. In order, then, to comprehend the mythology of a people, we must learn their language, acquire their confidence, assimilating ourselves to them by joining in their every-day life, their religious life, even as far as possible in their intellectual life, by remembering with intense earnestness the reasonings of our own childhood, by constantly striking every possible chord of human sympathy in our intercourse with those whose inner life we would study.

I think I have now sufficiently explained why I have entered into relation with the Zuñi Indians, and become a participator in their

* Lecture before the National Academy of Sciences, delivered in Washington, April 22, 1882.

religious practices and, so far as possible, beliefs, to the extent of acquiring membership in their gentile organization as well as in their priesthood; and my attitude toward the audience before me is that of an imperfect exponent of Zuñi mythology and belief.

Since my return from the Southwest, time has not permitted a sufficient study of those technicalities which have, during the past few years, been introduced into this class of subjects. I shall therefore have to proceed very simply, much as would a Zuñi priest, could he address you, in a discussion of his mythology and religion.

The Zuñi mythology, or theogony, is a reflection of Zuñi sociologic or governmental institutions, with the added feature of an almost universal spiritualistic philosophy. Hence it follows that a discussion of the one must include at least a brief description of the other. Like all well-known tribes of North American Indians, the Zuñis are divided into *gentes*, there being in their nation fifteen distinct clans or gentes. These again are combined into phratries, not political confederacies as among the Iroquois and Muscogee, but ecclesiastical bands, or, in other words, into secret medicine or sacred orders, of which there are, including the wonderful and supreme organization of the Priesthood of the Bow, thirteen. Based upon this sociologic structure, the government of Zuñi embraces three principles, the ecclesiastic, the martial, and the political, the outgrowths of which, in their order of precedence, are the priesthoods or caciqueships, the war chieftaincies, and the political chieftaincies. Supreme in national as well as in ecclesiastical office is the priest, or cacique of the sun, or *Pekwina*, immediately under whom are four secular as well as ecclesiastical high-priesthoods or caciqueships, the priesthood of the Pueblo, or temple of worship—in Zuñi *kia kwe armosi*—with the auxiliary office *tâ shiwan okia*, or "Priestess of Seed." Selected by, yet supreme over the latter four priests in martial and secular matters, are the two high-priests, or caciques of war, who may or may not be at the same time master-priests—*Pithlan shiwan moson atchi*—of the Order of the Bow. These six priests are designated in Zuñi ecclesiastical language "Priests of the Light or Day"; while resident in those special clans, which by heredity furnish the high-priesthoods (mainly the Clan of the Parrots, itself considered consanguineally descended from the gods), are numerous "Priests of the Night or Darkness," any one of whom may be chosen on the death of a priest of the light by the surviving companions. The two priests of war in turn create both the martial and political head chieftaincies, referring the latter to the four priests of the temple for acceptance or rejection. The martial head chieftaincy, or war chieftaincy, includes the third priesthood of the Order of the Bow, thus combining the ecclesiastical with the martial, and explaining the precedence of the latter over the political office. The third priest of the Order of the Bow, or head war-chief, then names three sub-chiefs, themselves necessarily

members of his own order. Likewise the head chief creates his own three sub-chieftaincies as well as the second political head-chieftaincy or chief, who in turn names his own three sub-chiefs. We find, then, that the democracy, or republic, of popular tradition, in its reference to the sedentary Indians of New Mexico and Arizona, is, like most other popular traditions regarding these comparatively unknown peoples, erroneous; that in reality their political fabric is set up and woven by an elaborate priesthood, the only semblance of democracy reposing in the power of the council—itself composed of all adults of good standing in the nation—to reject a political head chief as thus chosen, while the power of choosing a substitute remains still in the hands of the martial priests, and that of confirming him in the hands of the four priests of the temple. The latter are considered the mouth-pieces of the priest of the sun, just as the two priests of war are considered at once the mouth-pieces and, in martial and political affairs, the commanders of the four priests of the temple; and, again, the third priest of war, or head war-chief, and the first political chief, brothers to one another, yet differentiated in their functions, are considered to be the mouth-pieces of the two priests of war, the one in times of national disturbance, the other in times of peace. And yet, again, the sub-chiefs of the war-chief, as well as those of the two political head chiefs, are considered the mouth-pieces of their respective superiors.

Now, the organization of each one of the sacred or medicine orders of Zuñi, less in importance than the order of the priesthood of the bow, is a miniature representation of the national ecclesiastical and martial organizations—that is, each order has its *pekwina*, or high-priest, its four *kia kwe armosi*, or priests of the temple, its two *pithlan shiwan mosun atchi*, or priests of the bow, and in accordance with its special office its medicine or prayer-priest or master, and its sacred council. Less strictly secret, yet more sacred, and organized upon similar though more elaborate principles of office, is the church of Zuñi, the order of the sacred dances, or the *kâ kâ*, which is lodged in six places of worship—the half-underground *estufas* of the north, west, south, and east, the upper and lower regions of the universe. While the *kâ kâ*, as a whole, has its supreme high-priests, its priests of the temple, its warrior-priests, and its prayer-masters, each one of these six temples of worship has also its like special system of priesthood, with the added offices of song-priests or masters. Both in its organization as a whole and in its lesser organizations, the *kâ kâ* seems to be a perfect mirror, as it were, of the mythology of the Zuñi nation, just as the mythology is a reflection of the sociologic organization of the same nation. It is, then, to a study of the organization and functions of the *kâ kâ*, based upon a knowledge of the national sociologic organization, that we are to look for the most complete and clear exemplification of their system of gods, just as we are to look to the tradi-

tional rituals, prayers, songs, and sacred epics of this *kâ kâ* for a comprehensive idea of their mythology. Knowledge gained from both these sources may in turn be vastly added to, strengthened, and corrected by a close study of their most abundant and beautifully imaginative folk-lore.

Supreme over all the gods of Zuñi is *Hano ona wilona*, or holder of the roads of light, corresponding to the earthly *pekwina*, or priest of the sun, and represented by the sun itself. Beneath him is a long line of gods so numerous that I know not half their names, nor have I recorded them, but they are divided into six great classes: the celestial or hero gods (the demon-gods themselves perhaps the vestiges of a more ancient hero-god mythology), the elemental gods, or the gods of the forces of nature, the sacred animal gods, or the *kia pin a hâi* and *kia she ma a hâi*, the gods of prey or *wemar a hâi*, and the tutelary gods, or divinities of places. While *Hano ona wilona* is supreme over all, he himself, like the earthly sun-priest, is limited by his own high-priests among the gods—the celestial or hero gods, and they, in turn, by the demon-gods, while the two earthly offices of head political and war chiefs are represented, on the one hand, by the *raw* or water-wantings beings, or animal gods; and, on the other, by the *wemâr a hâi*, or gods of prey, while the priests of the night in the human organization (*tkwi-na-proa-a shi-wa-ni*) seem to be represented by the tutelar gods of the deistic organization. Not less important, then, because they are supposed to act in connection with the latter, are the ancients, or spirits of the ancestors, who form the body-politic of this great system of gods, and are supposed to serve as mediators between the mortals and the gods. In Zuñi belief they have also a definite place of residence assigned to them, notwithstanding which they are supposed to hold constant communion, even to the extent of occasional materialization with those whom they have left behind, to listen attentively to their prayers, and to represent them in some vague way to the higher gods of the Zuñi mythology.

While this great system of gods, like the *kâ kâ*, is organized, as a whole, not unlike the ecclesiastical and martial systems of the Zuñis, so also has each one of the six systems of gods, like each of the six *estufas* of the Zuñis, its offices of high-priests, priests of the house or temple, warrior-priests, etc. As an example of this special organization, let me speak of the gods of the ocean, who under specific names and attributes are further distinguished as "our beloved *Pe kwi we*, or sun-priest of the ocean; our beloved the *ona ya na k'ia a shi wa ni*, or priests of the temples of the ocean; our beloved mother, the *K'o hak o k'ia*, or the goddess of the white shells; our beloved, the three great warrior-priests of the ocean, *kia chla wa ni, ku pish tai a*, and *tsi k'ia hâi a*, in whom we do not fail to recognize the two master-priests of the bow, and the third priests of the bow, or head warrior-chief of the martial organization. The lesser personages of Zuñi

government are finally represented by the sacred animal gods of the ocean.

Let me give, as illustrations of the deistic conceptions of the Zuñis, without special reference to their rank in this governmental system of the gods, the names and supposed attributes of a few of the principal gods of Zuñi mythology. *Hâno ona wilona*, or the "holder of the roads of our lives," the supreme priest-god of Zuñi mythology, is supposed to hold as in his hands the roads of the lives of his human subjects, is believed to be able (to use the language of a Zuñi) to see (or perceive) not only the visible actions of men, but their thoughts, their prayers, their songs and ceremonials, to will through his lesser deities whether a thing shall be or shall not be in the course of a human life. I once asked a priest in Zuñi, who was about to go forth on a hunt, "Do you think you will lay low a deer this day?" and he said, "*Ooth-lat hâno ona wilona*" (as wills or says the holder of the roads of life). Immediately below *Hâno ona wilona* are the gods *Ahai in ta* and *Ma 'tsai le ma*, the two great deities of the priesthood of the bow, anciently known as *Ua nam atch pi ah ko'a*, the beloved both who fell (for the salvation of mankind). They are supposed to be twin children of the sun, *Hâno ona wilona*—mortal, yet divine. They were the guiders of mankind from the four great wombs of earth, the birth-place of the human family, far eastward toward the middle of the world; but, on reaching the eastern portion of Arizona, in the great exodus of the Pueblo races, they are supposed to have been changed by the will of their grandfathers—four great demon-gods—into warriors, and ever since have been the great gods of the order of the priesthood of the bow, and the rulers of the mountain-passes, and enemies of the world. Just so the young man, in modern Zuñi life, who lives for years in peaceful industrial pursuits, and all at once becomes chosen as a proper person for membership in the Order of the Bow, is induced to take a scalp, and henceforth becomes a ruler of his people and his world, a warrior and a member of that most powerful of priesthoods. These two gods are supposed to have been the immediate ancestors of the two lines of priests who are now their representatives, the high-priests of the Order of the Bow; from them, in one unbroken line, has been breathed the breath of *sa wa nikia*, or the medicine of war, from one to the other of the members of their household, the *a si chlan shi we ni*, or their children, the priests of the bow, just as has been in the belief of the Roman Catholics the unbroken apostolic succession. Through their wills over the *kia sin a hai*, or annual gods, with the consent of *Hâno ona wilona*, or the "holder of the roads of life," are the roads of man's life divided, or the light of his life cut off—figurative expressions for death in the highly poetic language of the Zuñis. Prior to their creation war seems to have been a secondary element in the existence of the Pueblo race; such as it previously was, however, it was represented by the great ancient god of war, the hero

of hundreds of folk-lore stories, *Atchi a la to sa*, or "he of the knife-feathered wings." He is supposed to carry ever about him his many-colored bow, *a ni 'to lan*, or the goddess of the rainbow, to walk upon his swift arrow, *wi lo lo a'te*, turquoise-pointed god of lightning, and to be guarded on the right and the left by his warriors, the mountain-lion of the North and the mountain-lion of the West.

Among other beings of ancient Zuñi mythology we have the marvelous example of *Oohe pololon*, or "the god of the north wind," whose breath sends the cold winds from the north region and drives the sands of the southwestern deserts, which have been stirred up by the will of the gods of the mountain. Dark and gloomy, like the clouds of the north-land home, ferocious with his shining teeth and glaring pendant eyeballs, wild with his iron-gray halo of ever-waving hair and beard, *Oohe pololon* is one of the most terrific of Zuñi demon-gods. Then we have the gentle moon, mother of the women of men, through whose will are born the children of women, the representative in this system of deities of the *Shewan okao*, or seed-priestess, younger sister of the priests of the temple; and the sister of the moon, the beautiful goddess of the ocean, through whose ministrations are awakened the loves of the Zuñi youth, and the good fortune of trade is secured.

While those gods in Zuñi mythology remaining unknown to me are legion, yet I might continue for hours to mention gods and their attributes; as for instance, "he who carries the clouds from the ocean of sunrise to the ocean of sunset and scatters them through the heavens between"; *Kwe le le*, or "he who infuses the roots of all trees with the spirit of fire, and swings his torch in mid-air, and it forthwith bursts into flames"; *Te sha mink'ia*, or "he who dwells in the cañons and cliffs of the mountains, ever echoing the cries of his children, men and beasts of mortality."

Interesting among the hero-gods is the great priest of all religious orders save that of the bow, *Poskai ank'ia*. In the days of the new, yet not until after men had begun their journey toward the east, he is supposed to have appeared among the ancestors of the Zuñis, the Taos, the Coconinos, and the Moqui Indians, so poor and ill-clad as to have been ridiculed by mankind. He it was who taught the fathers of the Zuñis their architecture and their arts, their agriculture and their system of worship, by plume and painted stick; but, driven to desperation by the ingratitude of his children, he vanished beneath the world, never to return to the abodes of men—yet he still sits in the city of the sun, ever listening to the prayers of his ungrateful children.

Let me add one more example: that of *Kia nis ti pi*, or "the great water-skate," who with his long legs measured the extent of the earth as with a compass, and between the oceans of sunrise and sunset determined the center of the world as the home of the Zuñis. He is represented by a peculiar figure, and this introduces us to a new depart-

ment of the subject—the conventional system of pictographs whereby the Zuñi sacred orders illustrate their mythological ideas. It is first to a close study of the mythology and theogony of the Zuñis, and then to that of the conventional forms of art among these and kindred peoples, that we are to look for the key to the mysterious and unnumbered pictographs of the great Southwest.

Interesting for comparison with Eastern mythology is the study of the phallic and the serpent symbolism as they occur in highly developed forms among the Zuñi Indians. Yet, again, interesting because of the light that it throws upon the development of human religions and mythologies is the study of the influence of environment, physical, biologic, and sociologic, as exemplified by the religion and mythology of the Zuñis.

I regret most deeply that in the limited time allowed me to-day I can not go into a discussion of these various questions, and into a production of the hundreds of facts illustrative of them which I have in my possession; but that I have time only to add that, as further illustrative of the connection between the Zuñi sociologic and the Zuñi mythologic systems is the fact that no general names for chiefs of all the departments—ecclesiastical, martial, and political—are to be found in their language, nor is there a general name for their god-priests, hero, demon, animal, elemental, celestial, or tutelar. Yet the term *awa nu thla* includes the political and martial chiefs in Zuñi government, just as does the name *k'ia pin a hâ i* include their representatives, the sacred water and prey-gods, of Zuñi mythology.

ASTRONOMICAL PANICS.

By DANIEL KIRKWOOD.

WHEREVER science has not been cultivated, all new and startling appearances in the sky are regarded as supernatural. But a few years since a shower of meteoric stones fell in India, the fall being attended by terrific explosions. The alarmed inhabitants of the district believed these masses of rock to have been thrown by their deities from the Himalaya Mountains, and with great veneration gathered up the fragments to be kept as objects of religious worship. Nor need we smile at this example of recent superstition. In the most civilized countries of the ancient world such phenomena as the aurora borealis, total eclipses, comets, and meteoric showers, were viewed as miraculous displays of divine power, and generally as forerunners of impending disasters. A brief account of some of the panics thus produced may not be without interest.

No one who has seen the more brilliant displays of the northern

lights—the splendid coronal arch, the columns tinged with various colors and moving in silent grandeur upon the midnight sky—can wonder that in a superstitious age their appearance should have excited the utmost consternation. Before the eighteenth century no physical explanation of such displays had been suggested or even thought of. The phenomena appeared suddenly and unexpectedly, and could not be referred to natural causes then known. The excited imagination saw armies mustering in the sky, brandishing their spears and raising aloft in quick succession their bloody lances. A very brilliant aurora seen in England, in 1575, is described by a writer of that period as a chasm formed in the northern sky, in which "were seen a great many bright arches, out of which gradually issued spears, cities with towers, and men in battle array; after that there were excursions of rays in every direction, waves of clouds, and battles in which some were fleeing, some pursuing, and others wheeling around in a surprising manner." If panics of this nature have ceased, the fact is due to the ever-advancing light of physical science.

One of the most noted eclipses in history is that recorded by Herodotus, and which occurred in the year 585 B. C. The panic produced by this eclipse put an end to the war between the Medes and the Lydians. A great battle was in progress, when, suddenly, day was turned into night by a total eclipse. The contending armies, struck with consternation, at once laid down their arms and hastened on both sides to conclude a peace.

THE ECLIPSE OF LARISSA.—Xenophon, in his "Anabasis," Book III, chapter iv, relates how the excitement and alarm produced by a total eclipse led to the surrender of a city. When the Persians obtained the empire from the Medes, their king besieged the ancient city of Larissa, but failed to capture it till, finally, the inhabitants, terror-stricken by the darkness of a solar eclipse, lost all courage, and so the city was taken.

A total eclipse of the sun was visible at many places in Europe on May 12, 1706. Professor Grant relates, in his "History of Physical Astronomy," that in many parts of the city of Geneva persons were seen during the totality "prostrate on the ground and offering up prayers, under the impression that the last day was come."

An ancient writer, in describing the great meteoric shower of the year 1202, says: "The stars flew against one another like a scattering swarm of locusts, to the right and left; this phenomenon lasted until daybreak; people were thrown into consternation and cried to God, the Most High, with confused clamor." Similar consternation and alarm were exhibited during the great meteoric display of 1366. An historian of that time says, "Those who saw it were filled with such great fear and dismay that they were astounded, imagining that they were all dead men, and that the end of the world had come."

The terror and alarm produced among the colored people of the

South by the great star-shower of 1833 have been so often described that the details need not here be repeated. I may, however, remark in passing that this shower was derived from the same meteoric swarm that produced the displays of 1202 and 1366, to which I have referred, and which returns at intervals of thirty-three years and three months.

In former ages comets were regarded as signs sent directly by the Deity to announce coming wars or fatal disasters. The degree of terror which they excited was proportioned to the size of the comet or the form and length of its train. A great comet, believed to have been that of Halley, appeared in April, A. D. 1066, the year in which William the Conqueror invaded England. This comet was looked upon as the forerunner of the conquest, and produced universal alarm. "The new star means a new king," was the common expression of the day. All writers of that period bear witness to the splendor of the comet of 1066.

But the accounts of all great comets in ancient times furnish similar instances of superstitious dread and consternation. Of a different nature was the alarm produced among the ill-informed in 1832 by the baseless expectation of the earth's collision with Biela's comet. It had been announced by astronomers that on a particular day a part of the earth's orbit would be included within the nebulosity of the comet. This statement was misunderstood by the general public, and a coming together of the earth and the comet was by many apprehended. Astronomers well knew, however, that our planet would be millions of miles from the intersection of the two orbits before that point could be reached by the comet.

The latest instance of supposed danger from a comet is that founded on a misapprehension of an article by the distinguished Mr. Proctor. In 1668 a large comet appeared and passed very near to the sun's surface—probably through the upper strata of its atmosphere. The great comet of 1843 moved so nearly in the same path that it was supposed by some astronomers to be a return of the same body; the period being one hundred and seventy-five years. But the path of the bright comet seen in the southern hemisphere in 1880 coincided still more nearly with that of the comet of 1843, and these dates would indicate a period of only thirty-seven years. Either, therefore, the period is becoming rapidly shorter, or the comets are separate bodies moving in orbits which, within the limits of the planetary system, are nearly coincident. The latter alternative has, I think, the greater probability. The theory, however, that the comets of 1668, 1843, and 1880 were returns of the same body, and that its orbit is converging with great rapidity, has been defended as affording a plausible explanation of the similarity of elements. At a meeting of the Royal Astronomical Society of London, May 14, 1880, Mr. Marth, a well-known astronomer, remarked as follows:

"Supposing this comet of 1843 is the same as that of 1668, it would

not be very wonderful that it should reappear now after thirty-seven years, instead of one hundred and seventy-five years. The velocity of a body moving in the solar system depends simply on its distance from the sun, and on the major axis of its orbit. If the velocity is reduced by a resisting medium, there will be a reduction of the major axis, and there is nothing whatever unreasonable in the supposition that, however weak the corona may be, its resistance would have a very great effect upon the motion of a comet which rushes through it, so that I should not be at all surprised if it should turn out that this comet of 1880 is the same as the comet of 1843 and that of 1668, and that its revolution has been so much affected that possibly it may return in, say, seventeen years."

These remarks of Mr. Marth were some time since quoted by Mr. Proctor, and made the basis of an article which in unscientific circles produced to some extent a most absurd sensation. Mr. Proctor's remarks on the subject have been misinterpreted as indicating the probable destruction of life upon the earth about the close of the present century. His language, however, though somewhat unguarded, expressed no such opinion.

The three comets named above approached nearer the sun than any other known, except, perhaps, that of 1680. In fact, when nearest the sun they actually grazed the solar atmosphere, or passed through its outermost portions. Now, it is well known that the motion of a planet or comet through a resisting medium continually lessens its distance, and hence accelerates its velocity. Messrs. Marth and Proctor assume that the passage of the comet of 1668 through the outer portions of the sun's atmosphere reduced its previously long but unknown period to one hundred and seventy-five years, so that its next appearance was in 1843. The perihelion distance at that date was still less; the comet met with greater resistance, and the period was shortened to thirty-seven years. The time of revolution would thus be lessened at each successive return, and ultimately the comet would plunge into the sun. Striking the solar surface with a velocity of three hundred and fifty miles a second, the amount of heat produced by the concussion and radiated to the earth might raise the temperature to such a degree as to destroy life upon our planet. Such are the conjectures suggested in Mr. Proctor's paper. Let us briefly consider them.

In the first place, the *fact* on which the theory of the supposed catastrophe is based—viz., the identity of the three comets—is extremely doubtful. It is much more probable, in view of all the circumstances, that they are different bodies moving in similar orbits.

Again, the period of seventeen years, fixing the comet's next return, according to Mr. Marth, about 1897, was the merest conjecture, not founded on any mathematical calculation whatever. It is true that the passage of a comet through the sun's atmosphere would short-

en its period at each return. The absorption of the comets of 1843 and 1880 by the sun's gaseous envelope, at some time in the distant future, is therefore by no means improbable. Such results are not known to have occurred in historic times; but, if the sun is gradually contracting—in other words, if its diameter was once considerably greater than at present—any comet passing so near the center as that of 1880 would have plunged so deeply into the sun's atmosphere as to be absorbed into its mass. It is true, moreover, that, when the motion of a body is arrested, such motion is converted into heat. If the earth were stopped in its orbit, its fall upon the sun would produce an amount of heat equal to that now radiated in ninety years. If the mass of the comet be $\frac{1}{3000}$ that of the earth, the heat produced by the impact would scarcely be equal to that now radiated in seven days; or, if the cometary mass be only equal to that of a globe one hundred miles in diameter, and of the same density as the earth, the additional amount of heat would be less than that now supplied in a single hour. It may further be remarked that the collision would be as likely to occur on the hemisphere turned away from the earth as on that turned toward us.

But let us assume that the great southern comet of 1880 was in fact a return of the comet of 1843, that its present period is about thirty-seven years, and that in consequence of its passage through the outermost strata of the sun's atmosphere its period must be shortened more and more until it falls upon the sun's surface. The solar atmosphere is known to be very rare from the fact that matter thrown out by the sun's eruptive force has been seen to ascend to a height of two hundred thousand miles. The resistance which it would offer to the comet's motion would therefore be slight, and in all probability several centuries would elapse before the comet's course would be terminated by its falling upon the sun. Instead, therefore, of a sudden catastrophe, we should have a gradual dissolution of the comet; portions becoming absorbed by, or incorporated with, the solar atmosphere at each successive perihelion passage. The apprehension of danger to the earth from a great and sudden increase of the sun's heat is, therefore, without any reasonable foundation.

It is due to Mr. Proctor to say that he did not designate the year 1897, nor indeed any other, as that in which the comet would fall into the sun, nor did he express the opinion that the collision would occur at the comet's next return. He merely remarks that, "if already the comet experiences such resistance in passing through the corona when at its nearest to the sun that its period undergoes a marked diminution, the effect must of necessity be increased at each return, and after only a few, possibly one or two, circuits, the comet will be absorbed by the sun." This statement, though perhaps incautiously expressed, is very different from that attributed by unscientific readers to its distinguished author.

THE STEREOSCOPE: ITS THEORY.

By W. LE CONTE STEVENS.

II.

ALL of the forms under which the stereoscope has come into general use have been devised with a view to creating to the utmost the illusion of natural binocular perspective by reproducing as nearly as possible the conditions of natural vision. That this end is not successfully attained is painfully felt by those who linger too long over an attractive collection of stereographs. To secure comfortable vision the muscles of the eyes must suffer no unusual strain. It is not easy to explain briefly how such strain is necessarily implied in the use of this instrument. Suffice it to say that, in looking at a point a few inches distant, the ciliary muscle which surrounds the crystalline lens in each eye is strongly contracted, and so is the muscle on the inner side of each eyeball. These contractions usually accompany each other, and to dissociate them is always more or less painful. The stereograph is but a few inches distant, but, because there are two pictures, the convergence of the visual lines is much less than normal; indeed, optic divergence is not unfrequently necessary. The unconscious interpretation which is put upon the retinal sensation is due partly to imagination; but also largely to the temporary condition of the muscles of the eyes. This includes not only the ciliary but also the rectus muscles, external and internal, by which the eyeballs are controlled, as the angle between the visual lines is varied. The effect of varying this angle is best studied with a modification of Wheatstone's stereoscope, which the writer has constructed for this purpose. A pair of conjugate pictures are chosen, which present as little as possible of mathematical perspective. A stereograph of the moon, divided at the middle, is one of the best for this purpose. The twin photographs are placed upon cross-bars (Fig. 12) which rest on graduated arms that are pivoted at the proper point in the base of a cubical block to which the mirrors are cemented. These arms move in contact with part of a circle, marked off in degrees at the circumference, the center of this being in the pivot. If the two arms make a straight line, and the pictures are properly adjusted, the visual lines must be parallel, for the eyes to receive the reflected rays. If pulled forward toward the observer, the visual lines must converge in order to retain single vision, and the angle of convergence is at once obtained from the circle. If pushed slightly back, as represented in the figure, single vision can be retained only by optic divergence. Most eyes that are healthy will be found capable of enduring a few degrees of such divergence. The real distance of the object is thus kept unchanged, and the card appears always directly across the visual line. The varia-

tions in apparent size and distance of the binocular image are very striking, while the perspective in the picture remains clear but also variable. If the stereograph be that of a reversed cone, this becomes apparently shallow, small, and near, or deep, large, and remote, ac-

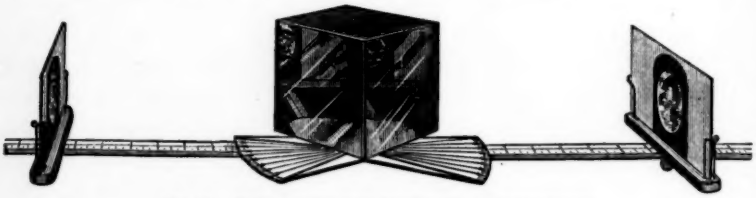

FIG. 12.—THE GRADUATED REFLECTING STEREOSCOPE.

cording as the excess of strain is upon the internal or the external rectus muscles. This instrument, indeed, is useful in quite a variety of binocular experiments. The visual effects are the same as those from an adjustable stereoscope with semi-lenses, but the limits of variation are far wider, and it is a decided advantage to obtain direct measurement of the optic angle.

Such experiments show very conclusively that the current theory of visual triangulation, whatever may be its application to normal binocular vision, has to be entirely discarded as an explanation of stereoscopic vision. As a theory it is beautifully simple, and at first glance appears eminently satisfactory; the only objection to it in relation to the stereoscope consists in the fact that it is untrue. Its expression may be found in most of our text-books of physics, and the diagram usually employed in explaining the stereoscope is that of Fig. 13, which is taken from Helmholtz's "Physiological Optics," the only change being in the avoidance of Greek lettering. This slight change also is made in the following translation from the French edition of this work, which received the last corrections of the distinguished author, who is universally recognized as the highest living authority on the subject of which it treats. After describing the arrangement of the prism-like semi-lenses, he writes: "The two drawings are placed, side by side, upon the same sheet. The right eye, R, looks upon the drawing, *a b*, through the prism, *p*; the left eye, L, looks upon the drawing. *a' b'*, through the prism, *p'*; the partition, *g*, prevents each eye from seeing the drawing intended for the other. The rays, *c p* and *c' p'*, sent forth by the drawings, are refracted by the prisms, following the directions *p* R and *p'* L, the prolongations of which cut each other at C. The convexity of the surfaces of the prisms has the effect of diminishing at the same time the divergence of the sheafs of rays, so that each eye sees at A B an image of the drawing that is presented to it. The object appears in relief at A B."

This explanation is distinctly geometric, the locality of each point of the image perceived being determined by intersection of visual lines,

R C and L C, as the attention is successively directed to different points in the field of view. If accepted at all, it must be accepted fully. If we suppose the semi-lenses removed, and that R and L together represent a binocular camera, the diagram shows the exact relation between this and an object to be pictured, and the admirable mathematical discussion which Helmholtz gives subsequently in full is strictly applicable. But, if the observer's eyes be too near together, or the stereographic interval be too great, the relation between the visual lines ceases to be the same as that between the camera axes, and we no longer have the conditions under which the geometric discussion can be applied. It is but due to Helmholtz to add that he closes with the following remark: "These conditions are not generally fulfilled for the photographic proofs and the stereoscopes of commerce." The same credit can not be given to the writers of the ordinary text-books. This qualification is of the last importance, for without it the theory is absurd, the apparent position of the image determined by intersection of visual lines being *behind the observer's head* when optic divergence is induced, and at an *infinite distance* when they are parallel. But, even when camera axes and visual lines bear the same relation among themselves, the abnormal muscular condition necessitated in stereoscopic vision introduces a disturbing element. The theory is hence not applicable at all to the stereoscope, but must be limited to the discussion of the binocular camera.

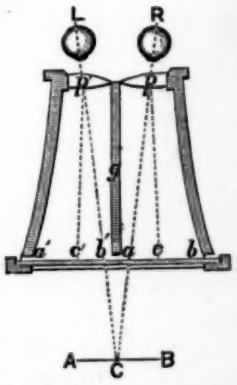

FIG. 13.—THEORY OF VISUAL TRIANGULATION.

With a view to enabling persons with untrained eyes easily to perform many of the experiments through which variation in appearance of the binocular image is produced by varying the conditions under which the same stereograph is viewed, the writer has devised an adjustable stereoscope (Fig. 14), which presents the additional very important advantage of rendering vision as nearly painless as it can be with the ideal stereograph, even although the stereographic interval on the one employed be so great as to produce only confusion, or strain of the eyes, when the common form of stereoscope is used. Instead of being fixed in position, the semi-lenses are lightly rested in a pair of boxes, with openings in front and rear so as to transmit the light. Attached to the partition between them are a pair of springs against which the thin edges of the semi-lenses are pressed by adjusting-screws in contact with their thick bases. By turning these so that the glasses are pressed as close as possible together, the light which enters the eyes passes through the thicker part of each glass, where the planes that may be supposed to touch the opposite curved

faces are nearly parallel. The rays are hence but little deviated in transmission, and the condition is the same as that in the ordinary stereoscope. Vision is then as comfortable as can ever be expected, when the stereographic interval is less than three inches. If it exceed this limit, the pain produced by the muscular strain of optic divergence, which would now be necessary, is prevented by giving a few

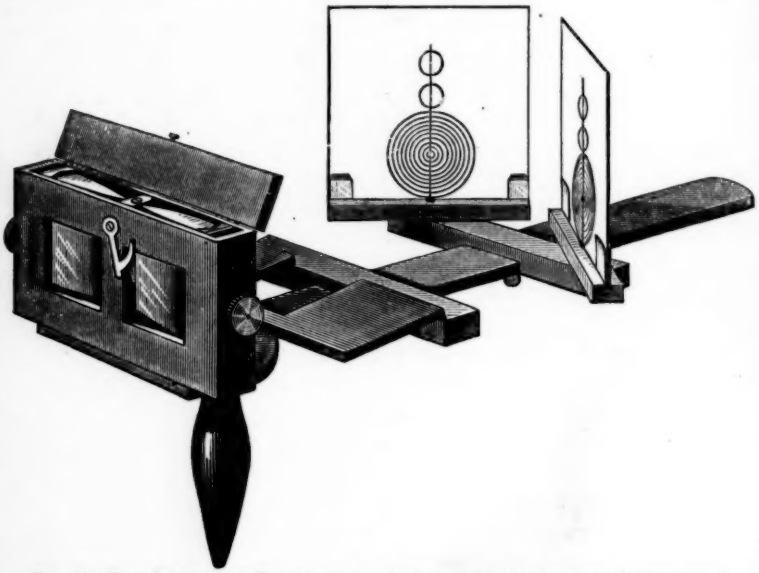

FIG. 14.—THE ADJUSTABLE STEREOSCOPE. ADJUSTMENT FOR NATURAL PERSPECTIVE.

leftward turns to each screw. The semi-lenses are at once pressed farther apart by the springs, the rays pass through at points where the opposite surfaces are more inclined to each other, and they are hence more deviated, so as to enter the eyes still without imposing the necessity of divergence. Indeed, if the stereographic interval be small, and free play be given to the springs, uncomfortable convergence may be induced at will. Under this condition a stereograph may be employed on which the interval is as great as four inches. If, while viewing the combined image, the semi-lenses be screwed closer together, the eyes will continue to adapt themselves, while fusion of images is retained, and any degree of divergence is thus induced that the observer may be disposed to endure. If the stereograph has been properly selected to illustrate the effects of muscle-reading, the image will appear to increase in depth as the visual lines diverge.

In front of the partition between the lens-cases are a pair of folding metal screens, of such width that when pressed flat against the wood they will hide from each eye the picture on the side belonging to the other, but when folded, as shown in Fig. 15 *s*, the whole stereograph becomes visible to each eye. On a movable cross-bar there is

another folding-screen of wood, which is shown pressed down in Fig. 14, and raised in Fig. 15. In the former condition it does not obstruct any part of the field of view, but in the latter it hides from each eye the half of the stereograph on its own side, and permits that on the other side to be seen through the opening at the middle. By now lifting the cover of the cases containing the semi-lenses, these glasses may be removed, and their places supplied with a pair of wedge-shaped prisms, which are introduced with their bases, instead of their sharp

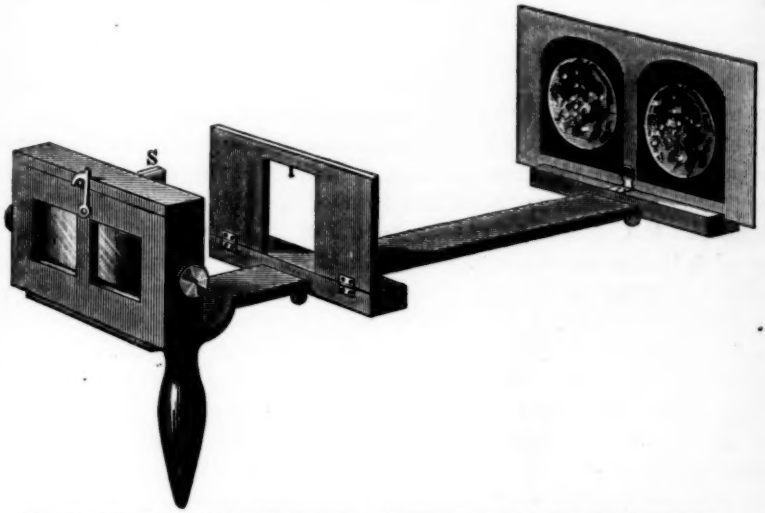

FIG. 15.—THE ADJUSTABLE STEREOSCOPE. ADJUSTMENT FOR REVERSED PERSPECTIVE.

edges, against the springs, while the screens are arranged as in Fig. 15. Pushing the cross-bar, intended to hold the picture, out to the farther end, a stereograph is put upon it that has been specially selected to show the effects of binocular perspective. Any stereograph in which mathematical perspective is not strong may be employed—that of the moon is excellent. Looking at this now through the prisms, instead of appearing convex it presents the aspect of a lustrous hollow hemisphere of crystal, through which on its farther side are seen the familiar dead sea-bottoms and jagged volcanic ridges. Our prisms and windowed screen have apparently turned the moon into a cup by bringing into each eye the picture originally intended for the other. On folding down the windowed screen, two extra moons spring into view. Comparing the middle concave image with the flat ones upon the two sides, it appears smaller and nearer, and this disparity is increased by pulling the stereograph nearer. As it approaches it grows shallower and slightly elliptic, the horizontal diameter becoming shorter; for, as the card is brought nearer, its plane becomes more oblique to the direction of the rays, which leave it to be refracted by the prisms before entering the eye. To the combined cyclopean eye, while each circle

must appear as an ellipse because viewed obliquely, the illusion is that there is no obliquity of vision, but that a narrow cup is suspended directly in front; while the pictures that are really in front of each separate eye appear, without relief, out at the two sides.

If the attention be carefully directed successively to the foreground and background when binocularly viewing a properly constructed outline stereograph, it will be found that perfectly distinct vision of the whole picture at any given moment is not usually possible. The distance between corresponding background points exceeds that between similar foreground points. This excess we shall call the stereoscopic displacement. If it be considerable, a pair of corresponding background points must be seen double, or imperfectly combined, when the foreground is distinct. In transferring the attention, then, to the background, slight associated contraction of the external rectus muscles is necessary to secure perfect combination of corresponding points, and this instantly suggests the idea of greater distance for these. Thus, as the attention is given to different parts of the picture, the tension in the muscles of the eyes is continually varying, and this is one important element in determining our binocular perception of solidity. Unless the attention be very carefully given to it, we are apt to overlook the successive duplication in different parts of the field of view. If the stereoscopic displacement be small, the perception of such duplication may be quite impossible, while the appearance of solidity, or of perspectiveness, as it has been called, remains distinct. The stereograph, represented in Fig. 16, has been specially constructed to exhibit a variety of different stereoscopic displacements. It may be viewed either with cross-vision, or with the aid of a card placed edgwise upon the triple line at the middle, or by placing the page in front of the semi-lenses of a stereoscope. Supposing the last of these methods to be employed, there will be seen at the top of the field of view a truncated cone, with a dot at the center of its lower base, and a pair of projections from the circumference of the

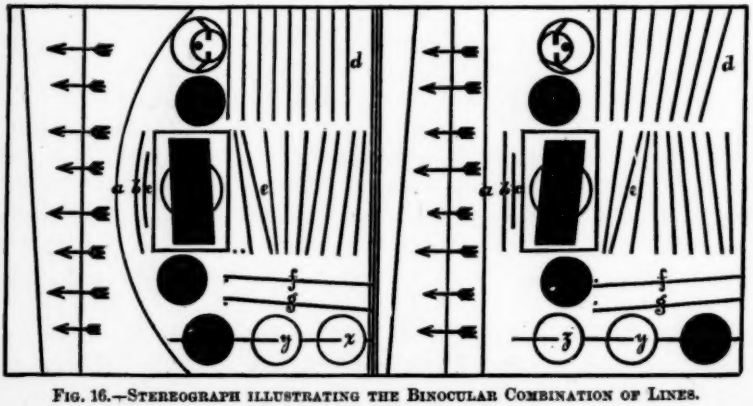

FIG. 16.—STEREOGRAPH ILLUSTRATING THE BINOCULAR COMBINATION OF LINES.

upper base. When the latter is made an object of attention, two dots are seen on the lower base, which apparently broadens out on the two sides; but the moment the attention is concentrated upon them, unless the observer is a little skilled in indirect vision, they fuse into one, and four instead of two projections are seen at the upper base, which in turn has broadened out. Indeed, very little skill is needed to perceive the distinct duplication of the entire upper base. At the middle of the field of view is an inclined black parallelogram, on which no duplication of any part can be perceived, except by a very steady gaze or by comparison with the black circles above and below; and these in turn are made to appear at different distances from the observer. The circular arc and straight line, each marked *a*, combine into a distorted parabola, in which the concavity is perfect at the middle, but at the top and bottom it breaks into two separate lines. The resultant of the lines marked *b* is quite as distinctly curved, but many persons will fail to notice any duplication at all; and this remark applies still more forcibly to the resultant *c*. The group *d* forms a warped surface; but, if the resultant line at its right be fixedly examined, it will be seen as an oblique cross, the combination being effected only by motion of the eyes. The group *e* presents still greater difficulties. The pair *f* are nearly horizontal, and are coalescent at the middle, but not combined at the extremities; each component hence appears no longer straight. The arrows at the left point obliquely, some toward and some from the neighborhood of the observer; but, if the gaze be rigidly directed to the vertical rod on which they are fixed, a pair of well-practiced eyes will perceive some of them to have very mobile double heads. The circles *x*, *y*, and *z* have a common axis, and are successively nearer to the observer; *x* and *z* are highly lustrous, and, when either is regarded separately, *y* is by indirect vision seen slightly double.

The two halves of this stereograph are strikingly dissimilar, but the principle which it illustrates enables us to secure stereoscopy with a pair of absolutely similar figures by so adjusting these in position that advantage may be taken of the almost spherical surface of the back of each eye. The geometric explanation of this is unsuited to the present article.* It may be sufficient to state that, if the two pictures be oppositely inclined to the visual lines, instead of being directly across these, the retinal images must be dissimilar, and the subjective combination of these must hence present the appearance of relief, which may be varied at will by varying the inclination of the cards.

The theory of associated muscular action which has been illustrated, while undoubtedly true, is still not sufficient by itself to explain all the phenomena of stereoscopy. The perception of distinct relief is possible when the card is illuminated with the electric spark. No motion of the eyes is attainable during so minute an interval. It is

* See "American Journal of Science" for April, 1882, p. 297, and May, 1882, p. 359.

possible also, when the stereoscopic displacement is so small, that not the slightest duplication of images can be distinguished with even the keenest vision. When this displacement is large, the play of the eyes is necessary to the completeness of the perception; but, in any case, the illusion is complex. The perception of double images is doubtless one important element; but when these are too minute to be distinguished, we are driven to other resources for an explanation.

Every one has noticed that each instrument in an orchestra has its own peculiar quality of sound, each singer in the cast of an opera his own vocal timbre. The explanation of this is no longer a mystery since Helmholtz analyzed, by the aid of resonators, what had eluded analysis by the unaided ear, and showed that the difference in quality between tones, nominally the same from different sources, is due to minute modifications upon sensations, corresponding to small air-waves accompanying those which produce the fundamental tone. By a well-known system of graphic representation, let the curve in Fig. 17 stand for the fundamental note; if this be simple, the curve is perfectly regular. But in fact it is accompanied by a group of smaller waves

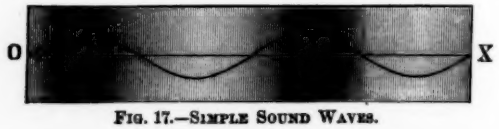

FIG. 17.—SIMPLE SOUND WAVES.

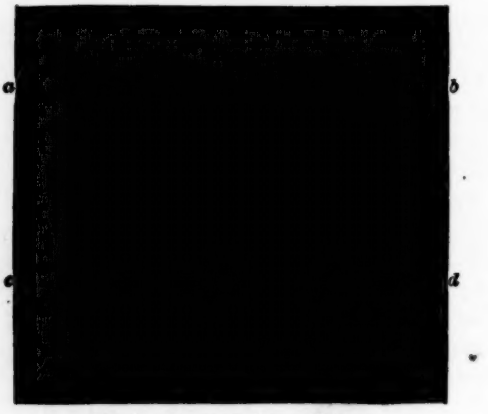

FIG. 18.—COMPLEX SOUND WAVES.

(Fig. 18, *a b*); when all are graphically combined, the curve is modified (Fig. 18, *c d*), and so is the actual sensation. With the same fundamental a different series of overtones would have produced a different resultant curve and sensation. The first of these resultants may represent *c'* from a soprano's voice, the other *c'* from that of the tenor, each sending into the ear 264 complex thrills per second. Without being absolutely unisonant, they constitute a pair of dissimilar musical

sounds that coalesce harmoniously. A well-trained ear may pick out some of the overtones without the aid of resonators, and perceive in the background a few duplicated sound-images; but the great majority of them are so faint that their presence can not be perceived apart from each other, or from the fundamental to which they give character. The rich combination of all stands out in strong musical relief, compared with what each voice alone would yield, or with the sweet but thin sound of a tuning-fork that sings forth the same fundamental pitch.

This principle relates to the combination of sensations, whatever may be the cause of dissimilarity among the components of the group. We have not the data from which a binocular image can be graphically expressed as a curve, for the dissimilarity of the components is not due to interference of waves of light. But the facts suggest kinship between the modes of sensation in the two cases. The dissimilar groups of light-images arouse sensations that are simultaneously conveyed to the brain, and the proper interpretation at once comes as the product of past experience. All we can affirm is, that experience has taught us to interpret retinal sensations which are slightly different in the two eyes, as the signs of an external object possessing three dimensions in space, when the images are produced upon parts of the concave surfaces which bear to each other the relations that would be imposed by the presence of such an object if naturally viewed. Such experience has been acquired by each of us individually, and probably with exceeding rapidity in consequence of inherited tendencies. It is therefore not necessary that the localization of what we see in the stereoscope should be limited to cases of optic convergence, or the perception of relief to those in which double images can be distinguished.

Our discussion has led us from the domain of physics to the confines of metaphysics. Explanations are at best only relative, and the psychologist, the physiologist, and the physicist must join hands in working out the problems of binocular vision. The progress made during the last half-century invites the hope that much may yet be accomplished before the next century brings us its morning greeting.

THE JEWS IN EUROPE.*

By Dr. J. VON DÖLLINGER.

I.

THE Academy celebrates to-day the birth of its royal head and gracious protector. Such a festival is, first of all, devoted to feelings the simplest, purest, and most elevating—love, reverence,

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gratitude. But it is also an occasion on which we are glad to think of our sovereign as weighing and pondering the affairs of his people, and the general condition of Germany; and passing under review the most important events of the time, carefully measuring their gravity. And so our thoughts turn naturally to the most recent events, to the serious problems, which are now pressing with so loud and urgent a voice upon our attention.

Not the least of these is the Semitic question, which has been agitating Germany for some years. The parties stand sharply over against one another, and as, in the thirteenth century, the cry was "Here Guelph, there Ghibelline," so now there sounds through the German lands, "Here Semite and friend of the Semite, there anti-Semite." With no little astonishment have we perceived that the conflict rages most violently just in the principal city of the empire, and even among those belonging to the aristocracy of culture. And, although the south of Germany is thus far much less involved in the agitation than the north, the forces in motion there are not without influence in our own vicinity. In our days, science may no longer, as was formerly the case, keep aloof in self-contented attitude from the great mart of life; rather has it the strongest reasons for participating, with the ripest results it has reached, in the solution of the problems of our age and nation, and for allying itself, to the end of mutual advantage, with all clarifying and quickening social forces.

So let one of the offerings presented by the Academy, on this the natal day of its royal protector, be an attempt to show how these things have come to be: how the knot, the manner of whose loosing no one is now able to indicate, has gradually twisted itself; and how History, wise guide of life that she is, holds up to the new errors that are threatening us the warning mirror of the errors of the past.

The fortunes of the Jewish people make, perhaps, the most impressive drama in the history of the world.

The Greek tragedians dwell with predilection on the *Hybris*, the arrogant misuse of power, as the dark fate that draws men on to destruction. In the fortunes of this people we encounter, as it were, an *Hybris* made up of religious fanaticism, vulgar avarice, and instinctive race-aversion. It was the result of that moral and intellectual infirmity which, for many centuries, has affected the highest as well as the lowest classes, and which still to some degree exists in wide circles, although kept in bounds by custom, fear, and public opinion. This infirmity was and is, in a word, a lack of the sense of justice.

We know well the powers that still to-day, in every possible form, whether open or disguised, are constantly repeating this one thought: "We alone are in possession of the full and saving truth, and therefore everything must be conceded to, and everything permitted us, that is necessary or serviceable in spreading and putting forward this truth." Where this principle prevails, and it did prevail in the entire thousand

years from 500 to 1500 A. D., and is still affirmed by those who adhere to the mediæval view of things—there even the idea of justice must appear as a damnable illusion. Such justice, we mean, as enables us to judge of men according to their education, inclination, and prejudices; as leads us to enter into the circle of their thoughts and sympathies, and to treat them accordingly; as leads us to excuse and bear with their departure from the lines of our own thinking, believing, and doing, and to respect their independence. The Christian religion has comprehended this justice in the command to love our neighbor as we love ourselves; but, by the rulers as well as the masses, by the teachers as well as the taught, by the educated as well as the ignorant, this supreme command has been misunderstood, ignored, and transgressed to an almost immeasurable extent.

As to the present condition of affairs in this regard I do not propose to speak. It is, however, easy to see that the civilization of a nation ranks the higher, the greater the number of those in it who are permeated by this higher spirit of justice, and the more calculated its institutions are to protect and manifest it. Where the relations of men to one another touch the religious field, we are accustomed to call the lack of this virtue fanaticism; and there have been times when even the best men and the noblest characters have thought and acted in a fanatical spirit. And so it has come about that, in judging of the past, we, on our part, are now called upon to display this justice to just those who were untrue to it in life, and denied it to their fellowmen.

Already, before the destruction of their capital and national sanctuary, the Jews were the most wide-spread of all peoples, and, when Strabo said that there could not be found one place in the world which did not harbor Jews, he spoke of a world comprising all the lands about the Mediterranean, and extending, in Asia, as far as into the Perso-Parthian Empire. By reason of transportations *en masse*, of half-free, half-compulsory colonization, of wars, and commerce in slaves, and gradually also because their spirit of enterprise took the direction more and more of commercial pursuits, they had become a *diaspora*, which, while numerous particularly in the sea-towns, using for the most part the Greek language, and influenced on many sides by Greek culture, still everywhere held firmly together, and preserved its existence as a distinct community. Like other inhabitants of the empire, they enjoyed the benefit of the protection of the Roman law. In general, they were esteemed and even given preferment, rather than mistreated, by the emperors. Their elders, indeed, received certain immunities; firmly holding together, and helping and advancing one another, they were successful competitors in all branches of industry, *therefore—hated.* And if their rite of circumcision, their celebration of the Sabbath, their laws respecting food, and their shy habits of seclusion, excited much derision and contempt, there was still in their

cultus of the one purely spiritual God, who was represented by no image, a powerful attraction for the minds of pagans, who were surfeited with the numberless divinities of their religion. "Enemies are they of the gods as well as men"—such was the frequently pronounced judgment of the pagan populace on this nation, whose character was so mysterious to them. About the time of the Roman war in Judea, they fell, not seldom by thousands, as a prey to the fury of the heathen populace.

They won again, however, a center of religious life and a head: in the little town of Jamnia, in Palestine, the sanhedrim formed itself, whose presiding officer was honored and recognized as the patriarch of the whole nation; so there was at once a supreme authority and an academy.

But just at this time, and in consequence of the powerful influence of the zealots, which had been enormously increased during the late wars, Judaism withdrew convulsively within itself, the Pharisaic way of thinking became exclusively predominant, and cast out every foreign element, such as Hellenism and Essenism; while the Talmud, which held all the members of the Jewish body together and lay like an iron band about the nation, completed the separation, and all the more surely since the Roman laws forbade any to be circumcised who were not of Jewish birth.

However, the question of vital moment was, what attitude those who carried the future in their bosom—viz., the Christians—would assume toward the Jews. The earliest Church remained true in this respect to the example and word of its Master and the teaching of the apostles. It believed and taught: 1. That the death of Christ, for which the leaders of the Jews and a part of the people at Jerusalem were responsible, involves in no way the continuous guilt of the whole nation. On the contrary, Christ himself asked for the forgiveness of his crucifiers, and his prayer was heard. Peter, too, like his Master, excused their transgression on the ground of their ignorance. 2. The people is by no means outcast from God, even if their dispersion, the downfall of their state, and the destruction of their temple and capital, may be regarded as a divine punishment. *Israel remains the chosen people of God*, since God can not retract his choice and promise. At some future day, when the "fullness of the Gentiles" shall have come, the fullness of Israel will also believe, and make an harmonious fellowship along with Gentile believers.

Starting from this view drawn from the New Testament, the wisest and most eminent teachers of the Church exhorted that the Jewish people must be regarded as a brother who has for the time gone astray, but will sooner or later return to the Father's house, and in the mean time is always and will remain the bearer of irrevocable promises. Hence, they marked out the duty for Christians of indulgent and patiently enduring love toward the race, of which both Christ and the apos-

tles were members, and from which they did not wish to be separated. The most learned and original of the older fathers, Origen, declared: "They are and remain our brothers; but they will only unite with us when we, by our faith and our life, have stirred them to emulate our example." Even Augustine frequently said: "In the hearts of Christians the confidence lives, and is expressed by them continually, that the children of the present Jewish generation will some day melt into one faith with the Christians." This view of the earliest Church disappeared, however, when Christianity became the *state* religion, and Roman heathenism *en masse*, with its hate and contempt for the Jews, became converted, in part freely and in part through direct or indirect compulsion, to Christianity. Soon the synods forbade eating with a Jew; and Ambrose, who, while still unbaptized, was elevated to the bishopric of Milan, styled the burning of a synagogue in Rome by the populace an act pleasing to God, and called the Emperor Maximus, who desired its rebuilding, derisively a—Jew. There comes to be, with infrequent exceptions, a more hostile strain in the writings of Christians, and the name of brother vanishes; their remaining without the Church is explained no longer by ignorance, but by an ill-meant obduracy on their part. The hope of a future reconciliation is, indeed, held; but the reconciliation is placed as it were in the most distant corner of the future, in the last days before the final catastrophe and the judgment of the world. It seemed as if the prospect of living in community with Israel (when, moreover, according to the Biblical doctrine, Israel would retake the ancestral primacy) was so little to the taste of the Christians that they were anxious to restrict so unwelcome and vexatious a condition to a few days or months.

The Christian emperors had changed nothing of importance in their laws respecting the rights and liberties of the Jews until the year 439, when Theodosius II excluded them from all public, even municipal, offices. This law passed over into Justinian's Codex, and regulated their status in Europe as well as in the Eastern Empire.

In the West we encounter at the end of the sixth century the first forced conversions in the Frankish Empire; Avitus, in Clermont, and the kings Chilperic and Dagobert set the precedent. It was followed in the kingdom of the Spanish Visigoths on a large scale. There, where the bishops ruled the state, King Sisibut in the year 612 allowed the Jews only the choice of emigrating or being baptized. Many chose the latter, but turned back after a time to Judaism; and, as the result, there began a series of violent measures to keep them in the Church against their will, and to avenge their lapsing. This was in accordance with a decree of the national synod of Toledo—a fatal decree, which has cost more blood and tears than any law of heathen antiquity, since it served as a norm for innumerable deeds in subsequent time.

In the Frankish Empire the ordinances of the Episcopal councils

remained for a long time within the circle defined by the Emperor. The Jews were forbidden marriage with Christians, the ownership and sale of Christian slaves, and jurisdiction in court over Christians; further, Jews and Christians were not allowed to take a common meal, and the employment of a Jewish physician was forbidden. Bitter hostility against the Jewish people is breathed first in the Frankish Empire in the writings of the Archbishops Agobard and Amolo, of Lyons, about the year 848; the latter recommended Sisibut's action as one acceptable to God, and worthy of imitation—a bad sign of what was to come. However, these writings also indicate, first, that at that time the charge of a usurious fleecing of the Christians by the Jews was not yet brought forward; and, further, that the Emperor, the officers of state, and even the agricultural population, were well-disposed to the Jews, and that the state still protected them.

But with the end of the eleventh century a turn of things began, which proved full of disaster to the Christians as well as to the Jews and the pagans. The highest authority in the Western world had announced the principle of the religious wars, and found the means to foster them and continuously excite them anew. It had become an expiatory and saving work to conquer non-Christian peoples, and to plunder and destroy those who resisted; hence, it was unavoidable that the condition of the Israelitish people should take a much worse shape than before; and, although in general Europe was making steady progress in the formation of orderly civil governments, this progress was of no advantage to the Jewish people; rather did each century, until the Reformation, bring an increase of their misery. For the Israelite was in the eyes of the then existing Christians worse than an unbeliever; he was called in the official language of the Church *perfidus*—i. e., a man who deserves neither truth nor confidence. "Oremus et pro perfidis Judais" stood in the Liturgy for Good Friday, and all theologians and canonical writers of that time used the expression. The Jew should be avoided like one afflicted with a plague, even whose breath contaminates, or like a dangerous tempter, whose words hide the poison of doubt and unbelief. The laity were forbidden to speak even one word with him on the subject of religion.

When, therefore, the hosts of the Crusaders went out to war against the Mohammedans in Asia, they began slaying the Jews at home, and plundering their houses. And the kingdom of Jerusalem began its existence by burning the Israelites who lived there, together with their synagogues.

Those were acts of fanatical and untamed bands. For princes and peoples, for priests and laymen, the utterances of the Popes and councils respecting the rights and duties of Christians to the Jews were naturally accepted as giving the law. Before this, the Roman bishops had not concerned themselves about the Jews; their epistles and enactments during the first six centuries contain nothing about them, the

imperial laws appearing to have satisfied them. Gregory the Great protected them unweariedly against the acts of violence common in Southern Italy, and forbade forcing them into the Church. On the other hand, he sought to procure their conversion by vouchsafing privileges to them, and set up the doubtful principle, which was often evoked later on when forcible conversions were attempted, viz., if the Church does not win thereby those who have been bought over, it certainly wins their children.

From that time on, for nearly three centuries, the Popes are silent respecting the Jewish people. After the middle of the ninth century the first considerable assumption of power on the part of the Papacy took place under the Pseud-Isidore, Nicholas I, and his nearest successors. When Stephen VI (885–891) broke the long silence, a strong hostile feeling had already taken the place of the earlier mildness in Rome. The Pope wrote to the Archbishop of Narbonne, that "he had been plunged into deadly anxiety by the news that the Jews, those enemies of God, had become possessed there by royal permission of property in land, and that Christians lived together with these dogs, and even performed service for them, although, as a punishment for the death of Christ, all the pledges and promises which God had confirmed to them were canceled." With this the signal was given, and the new path entered upon on which men now proceeded to advance. It is true that the Jews were not seldom successful in obtaining Papal letters of protection. The injunction not to force them to baptism, or to rob or kill them, was often repeated; but, while on other occasions, even in matters of little consequence, banning, interdicting, outlawing, and other drastic means were threatened and applied, these bulls for the protection of the Jews consisted of general exhortations, and were of little use, because the penal sanction was wanting. The kings and high nobility set everywhere the example of lawlessly oppressing, abusing, and plundering the Jews, and we do not find that the Popes called them to account for this, or took the part of the oppressed against them. On the contrary, when Philip Augustus robbed and banished the Jews of France, Cœlestin III declared that the king in doing this had shown his ardent zeal in the cause of God; and when any temporal ruler, who was also an official in the Church, in order to be sure of his right to do so, asked for Papal authorization to drive out the Jews from his dominion, it was readily granted him. The declaration of Innocent III, that the whole people was condemned by God, on account of its guilt, to perpetual slavery, became the oft-cited Magna Charta for all those who lusted after the gains and possessions of the Jews; in accordance with it rulers and peoples acted. Nor could the impression it made be greatly diminished by the circumstance that the Popes supported the letters, which they from time to time gave for the protection of the Jews, by referring to the prophecy about a remnant of the people that should remain

over, in order to be converted in the last days. Such a remnant of the Jews, it was thought, would be preserved, if not in Europe, at all events in Asia.

The succeeding Popes held firmly to the principles and demands of Innocent III. If the Jews built a new synagogue, it must be torn down; the only thing allowed was to repair the old ones. No Jew could witness against a Christian; the bishops were to insist, even with the use of force, upon their wearing of the distinctive badges, the hat or the yellow cloth. This law respecting badges was particularly hard and cruel; for, in the frequent uprisings and tumults in the cities, the Jews fell so much the easier into the hands of the infuriated mob, which in this way recognized them at a glance; and in traveling they became the prey, without hope of rescue, of the robber-knights and highwaymen, who naturally looked upon every Jew as an outlaw. In Spain, permission was therefore given them to wear every kind of clothing in traveling, but the permission was soon taken back.

Especially did Eugene IV, who annulled the humane concessions made by Martin V, add to the sharpness of the ecclesiastical legislation, already pitiless enough, and the question was perforce raised how, if all this was fully carried out, could these men maintain their piteous existence at all.

Whatever ground the Popes had left untouched, was covered by the councils of the different countries; they forbade, for example, that a Christian should let or sell a house to a Jew, or buy wine of him. In addition to all this, came the oft-renewed orders to burn all copies of the Talmud and its commentaries—i. e., by far the largest part of the Jewish literature—on account of the passages hostile to Christianity that were said to be found therein. And then came again tortures, persecutions, and imprisonments in abundance. It seemed as if the mighty of the earth had only stones instead of bread for the afflicted people, and were disposed to give no answer to their entreaties and inquiries, other than that which the ancestors of the Jews once gave to the tyrant Herod, viz., when he asked what, then, he should do for them, they replied, to hang himself.

The new theory of the slavery of the Jews was now adopted and elaborated by the theologians and canonical writers. Thomas of Aquinas, whose views pass as unimpeachable in the whole Church, decided that the princes could dispose of the property of these men, who were condemned to perpetual bondage, just as they would of their own goods. A long series of writers on the canon law built upon the same foundation the assertion that princes and lords could forcibly dispossess the Jews of their sons and daughters, and cause them to be baptized. That a baptized child of a Jew should not be allowed to remain with its father was universally taught, and still is a demand of the Church. The princes, in the mean time, had greedily adopted the papal doctrine of the divinely ordained slavery of the Jews, and the

Emperor Frederick II based thereupon the claim that all Jews were his property as the Emperor, according to the then prevailing logic, that the master's rights over them had been transmitted from the old Roman emperors to him as their successor. His son, Conrad IV, already used the expressions, "servants of our chamber," and the *Schwabenspiegel** professed to know that "King Titus had given them over to be the property of the imperial chamber." King Albrecht demanded from King Philip of France that the French Jews be handed over to him, and later the Jews themselves said, in a memorial to the Council of Ratisbon, that "They belonged to the Emperor, in order that he might preserve them from entire destruction at the hands of the Christians, and keep them as a memorial of the sufferings of Christ."

After the fourteenth century, this servitude to the exchequer came to be understood and applied as a complete slavery: "You belong," says the Emperor Charles IV, in a document addressed to the Jews, "to us and the empire with your lives and possessions; we can order, do, and act with these as we like and as seems good to us." In fact, the Jews frequently went, like an article of merchandise, from one hand into another; the Emperor declared, now here, now there, that their claims for the payment of debts were annulled, and caused a large sum of money, generally thirty per cent, to be paid by the debtors into his own treasury.

The protection which emperor and empire were supposed to accord to the servants of the exchequer was often illusory, even when they were granted special privileges; as a matter of fact, they were without civil rights. Only where self-interest dictated, not to allow men in so many ways useful and profitable to utterly perish, did the governments step in. Otherwise everybody's hand was against them, from emperor down through all ranks of society to the very rabble. Often protection was assured them only for a limited time, at the end of which they were as good as outlawed, unless they immediately bought with large sums of money a renewal of the letter of protection. They were used like sponges—allowed to completely fill themselves, in order to be then as completely squeezed out. What happened in the year 1390 deserves to be kept in the memory of Germans as a constant warning. King, princes, nobles, and cities were, by reason of long wars, all alike in debt; then the example that had been already given by France was copied. At the Imperial Diet held in Nuremberg, all money-claims by Jews were annulled, and, instead of paying their rightful creditors the debtors paid in fifteen per cent of their indebtedness to the royal treasury! In this way, for example, the Duke of Bavaria, the Count of Oettingen, and the city of Ratisbon, each won one hundred thousand gold florins.

If a prince ever showed a disposition to favor the Jews of his land

* The book containing the statute- and feudal-laws of South Germany.—TRANSLATOR.

or any single individual, by bestowing perhaps a piece of land or an office upon him, a papal letter soon appeared warning and threatening with punishment, and reminding the prince that a son of the handmaid should never be preferred to a son of the free-woman.* Cardinal legates of the Pope had it decided at councils (as at Vienna, in 1267) that no Jew should be permitted in a bath-house or drinking-saloon or an inn; that no Christian should dare buy meat of a Jew, since he might thus be treacherously poisoned. The Synod of Salamanca, of the year 1335, declared that physicians of the Mosaic faith offered their services only because they wished to destroy, as far as they could, the Christian people, and so, in effect, the population of all Europe.

In this way the seeds of hate and detestation were sown, and wholesale murder was the harvest. Accustomed to the view that every Jew is a born enemy and debtor to the Christians, the nations, in a time when what was cruel and unnatural was credulously laid hold of with a kind of predilection and even eagerness, held the Jews to be capable of every crime, even the most improbable and impossible. After the twelfth century, the story went about that the Jews craved Christian blood, some imagined for their festival of the passover, others as a remedy against a secret hereditary disease; and, to get it, that they put a boy to death every year. In addition, a pretense was made of knowing that they crucified a Christian every year in mockery of the Redeemer.

If a corpse, on which there were signs of violence, or a dead child, was found anywhere, a Jew must have been the murderer; generally, the crime was supposed to have been committed by a number jointly, and torture was continued till it extorted confessions. Then followed horrible executions, and in many cases a general butchering of the whole Jewish population in town and country. An orderly, unprejudiced judicial procedure was not to be thought of. The judges and magistrates trembled themselves before the rage of the populace, which had its mind made up from the start, and held fast to the presumption that the most infamous deeds might be expected of every member of this murderous people. Occasionally, it was an image of Christ, which a Jew was said to have pierced with a knife or mutilated, that gave the signal for a massacre. After the year 1290, rumors of maltreated and miraculously bleeding Hosts were added. From Paris, where the first case had happened, the news spread to the neighboring countries. Very soon the possession of a similar miraculous treasure was coveted elsewhere; and now it appeared as if the Jews, seized by a demoniacal frenzy, at once believed and disbelieved an ecclesiastical dogma, and had an irrepressible desire for an agonizing death—so frequently were these ostensible outrages revenged upon them.

In London the Jews were murdered because they were suspected

* *Cf.* Paul's Epistle to the Galatians, iv, 22–31.—(TRANSLATOR.)

of plotting to burn the great city with Greek fire. The great plague, which in 1348 swept over and depopulated all Europe, could only, it was easily known, proceed from the Jews. The fact that the sober and temperately living people were much less affected by the plague than the Christians, converted the bare suspicion into a certainty. They had everywhere, in consequence of a great conspiracy, in which the houses of lepers had also taken part, poisoned the springs and wells, and even the rivers. In Zofingen it was pretended that actual poison was found in one of the wells. On the rack some Jews and lepers confessed to the deed. There hence burst forth a storm of fanaticism, of bestial revenge and vulgar avarice, such as has never before nor since been seen in Europe. The victims were counted in single towns by thousands. Many anticipated the rage of the mob by taking their own lives. To no purpose did Pope Clement VI declare in two bulls that the Jews were innocent. Those who saved themselves by a swift flight found an asylum only in distant Lithuania.

Still, not merely on account of religion and the fictitious crime did the popular hatred direct itself against the Jews; there was in addition a third motive, acting just as, if not more strongly. The Jews loaned money on interest, they were usurers; they carried on an indeed indispensable but none the less sinful business, and fleeced, so the saying was, the Christians. The accusation was not untrue, and yet unjust.

Popes and councils, supporting themselves upon an incorrect interpretation of Luke vi, 35,* have since the end of the eighth century with one voice and with a continually increasing rigor, condemned and visited with ecclesiastical penalties all taking of interest, in whatever form, on loaned capital. In the early Church, only the clergy were forbidden to take interest; but, as the influence of the Papal chair increased, the prohibition was extended to the laity also.

No distinction was made between interest and usury, but every stipulation for or taking of the slightest amount over and above the capital that had been loaned was forbidden by the Popes and councils, a prohibition from which there could be (as Alexis III, in 1179, declared) in no case a dispensation. To this Clement V at the Council of Vienna added the decision that it is heresy to assert that the taking of interest is not a sin.

Unendurable fetters were thereby placed upon all commerce and business; and Pope Gregory IX declared even the money advances, with interest stipulated, which maritime traffic requires, to be damnable usury. The Church had thereby placed itself in contradiction with the nature of things, with the indispensable requirements of civil life and of general trade; she might, indeed, prevent her own members from taking interest, but she could not command or compel

* The revised translation reads, "and lend, never despairing," in place of the old translation, "and lend, hoping for nothing again."—(TRANSLATOR.)

them to loan out their money without interest. On account of the general lack of ready money in a time when the supply of gold and silver metal was continually decreasing, and a currency to take their place had not been devised, everybody from the highest to the lowest came very frequently to a pass where they must borrow money; and since trade in money was strictly forbidden to the Christians, and could only be carried on by them when veiled under other forms of business or in roundabout ways, the Jews, who were excluded from other branches of industry and positions in life, entered upon it. *An industrious people the Jews have ever been.* As long as they formed a state of their own, their principal occupations were agriculture, horticulture, and the trades. In their hands Palestine had become one of the best cultivated and most fruitful lands of the earth. The Mosaic legislation was intended to encourage the improvement of the soil, and to further the cultivation of grain, wine, and oil. Further, in the first centuries after Christ, and after the destruction of the Jewish state, the people remained faithful to their old customs. Josephus, in the beginning of the second century, still praises the industry of his countrymen in their trades and in agriculture.

There is no evidence to be found in the Roman literature and the laws of the emperors that the Jews had given themselves up to shrewd bargaining and small trading, or in general had become a commercial people. The numerous Jews that lived in Rome appear to have been poor. Further, the violent and extremely bloody risings of the Jews in Egypt and Cyrene, and on the islands (of the Mediterranean) indicate that they did not form a commercial population or one dealing in small wares, for such a class of people do not often take up arms. Even as late as the tenth century, they formed a stationary population in Spain, Southern France, and even in Germany. This condition, however, they could not maintain in face of the hostility of the Church and of the people, and moreover, after the rise of the Italian maritime and commercial cities with their merchant-fleets, they lost their hold upon the commerce between the West and the Orient. The concentration of trade in the guilds and the exclusion of the Jews from ordinary intercourse with Christians made it impossible for them to become artisans. Just as little could they live on agriculture, since they were almost everywhere forbidden to own land. Cardinal James, of Vitry, who knew the Orient well, observes in the year 1244, "Among the Mohammedans the Jews ply handicrafts, although it is only the lower and despised branches that they occupy themselves with, but among the Christians they live on the business of loaning money." The thought forces itself upon us, how great a benefit would have been conferred upon the world, Christian and Jewish alike, if a cardinal or a Pope at that time had reflected upon this contrast between the Jews under the Crescent and the Jews under the Cross, and had drawn from it the practical inferences that lie so near at hand.

In addition, the physician's calling was as a rule closed to the Jews, although in Mohammedan countries it was precisely as physicians that they won high distinction; for the councils forbade a sick person, on pain of excommunication, to take medicine from a Jewish physician—it being better, as they declared, to die than to be healed by an infidel? They were further excluded from all schools, high and low. Whoever had a desire for knowledge must become a rabbi, and if, as a very rare exception, a prince, like Alfonso X of Castile, made use of Jewish mathematicians and astronomers, the education of these men was obtained in lands where the Koran ruled. The taking of interest on loans from strangers was permitted to the Jews by their law, and the supposed prohibition by Christ was believed at first by both parties not to be binding upon the Jews. The matter changed, however, after Innocent III. At the end of the twelfth century, theologians and canonical writers taught that, in accordance with natural law as well as the divinely revealed law of the Old and New Testaments, the taking of interest in general is forbidden and is a sin. Innocent III ordered, therefore, that the Jews should be compelled to give back the interest they had collected, and to this end introduced an expedient that had not been used before, viz., that Christians should be compelled, on pain of excommunication, to break off all intercourse with those Jews who refused to make the returns. This amounted, in case the programme was strictly carried out, to delivering them over to death by starvation. Hence arose sad confusion and conflicts of many kinds. The bishops, whose duty it was to pronounce excommunication, were disposed often to execute their task in good earnest; and the synods (for example, that at Avignon in 1209) urged them to do so. The princes, on the other hand, in whose interest and as whose servants the Jews carried on their money-lending, protected them; or, on the other hand, as happened in not a few cases, confiscated their entire property for their own use, on the plea that it had been gained by taking interest. Sometimes they even compelled Christian debtors to pay the outstanding interest into their own treasury.

Interminable confusion to clergy and laity was the result of the action of the hierarchy in forbidding the taking of interest, and the canonical writers vexed themselves to invent distinctions and find ways of escape out of the labyrinth. In innumerable cases they found themselves helpless in face of the actual circumstances and practically abandoned the principle, although in theory no one could attack it on pain of death. In real consistency, the Christians should have been forbidden to borrow on interest, since by so doing they enticed the Jews to sin. But Popes, bishops, clergy, were themselves often in a situation in which they must seek for a loan and pay the interest; in fact, the whole organization of the curia, the management of the system of benefices, the taxation of the clergy by the Popes, were calculated to make bishops, clergy, monasteries, and chapters liable to the payment

of interest to Jewish capitalists. Under these circumstances the canonical writers finally decided that, being in any case lost, it was immaterial whether the Jews committed a few more or a few less sins; the borrowing Christians, however, were excused by their necessities.

The interest demanded by the Jews was, it is true, exceedingly high, and often beyond the power of the debtor to pay, but this was a result of the value of money at the time, of the scarcity of coin, and above all, of the oppressive amounts which the Jews were obliged to pay to princes and town authorities. The Caorsines and the great Italian bankers put their demands just as high as the Jews, and where they got the trade in money into their own hands the desire arose, as for example in Paris at the beginning of the fourteenth century, to have the Jews back again, since their activity as money-lenders was, on the whole, in many ways beneficial, and at that time irreplaceable. They did for the northern countries and for Spain what was done for Italy by the bankers' associations of the so-called Lombards, and by the money-brokers of Asti, Sienna, Florence, and other cities, who were partly patronized and partly silently tolerated (and in either case frequently called into requisition) by the Popes and bishops. In France and England there was even at times competition between Lombard and Jew. The Emperor Louis's son, Louis the Brandenburger, issued in the year 1352 a public invitation to the Jews to settle free of taxation in his land, because "since the time when the Jews were destroyed (referring to the great massacre of 1348), there has been everywhere, both among rich and poor, a deficiency in ready money."

CHEMISTRY IN HIGH-SCHOOLS.

By ELISA A. BOWEN.

I HAVE, for some years, been trying to improve the teaching of chemistry in girls' schools. It is, of course, work of the most elementary character. I wished earnestly to make it, so far as it went, inductive study—in other words, to train the observing powers to select for themselves the significant facts; and to train the reasoning powers to draw for themselves, with some degree of independence, the more important of the general principles which we call the theory of chemistry.

When I began to teach this subject, about six years ago, the progressive teachers had become dissatisfied with the old plan of book-study or lecture, with experiments by the teacher. The best thing offered as improvement was the performance of experiments by the pupils themselves. This was certainly an important advance; and manipulation is, first or last, essential to any complete knowledge of

chemistry. But it is not all that is needed. *Mental* activity is the important thing.

I will illustrate the plan which has proved best in my own experience, merely saying, first, that even where pupils have studied physics, I have a preliminary drill to make sure the girls are quite clear about the forms of matter, the properties of liquids and gases, attractive and repulsive forces. I do not say a word to them about *chemical* attraction, because I wish them to study that out for themselves. Sometimes they have already learned by heart a definition from some book on physics; but, as Thomas Carlyle would say, "by the blessing of Heaven they have generally forgotten it."

I think the best experiment to begin with is the evolution of oxygen gas by heating the red oxide of mercury. This is not the easiest or the most convenient way of obtaining oxygen, but it is much the simplest process.* I do not usually tell my pupils anything—not even what the substance is which they are to make; but they know I shall question them closely about what they have seen. When the experiment is concluded—the gas tested with a glowing taper; the residue of mercury examined; and a little of the red oxide put into water and stirred, to show that it will not dissolve—I usually ask questions about as follows:

"When the jar was lifted from the water to the shelf, why did not the water fall out? Why did the water afterward sink in the jar? Did you see anything in the jar as the water fell? Why do you think there was anything in the upper part of the jar? What form of matter was it? How do you know that it was not air? How was it like air? How was it unlike air? Had it color or smell? Did it burn? What was it burned? Did the gas have anything to do with the burning?"† I then tell them the gas is called oxygen; and I write on my blackboard the name and symbol, with a list of the properties which they have just discovered.

I then proceed to ask: "What remained in the ignition tube at the close of the experiment? What form of matter was it? Did you ever before see anything with that shiny luster? What class of bodies have it?" Then I tell those who do not already know that it is mercury, and I give the symbol, Hg.

I then say: "Where were the gas and the liquid when that red powder was placed in the tube? What became of the powder? Did it take any force to separate the gas and liquid which you say formed the powder? What was the force? What sort of a force is heat? Do you suppose any force held the oxygen and mercury together? Do you know a general name given to forces which unite

* I always, of course, have ready a quantity previously otherwise made.

† I find that pupils will at first, of themselves, make the somewhat conventional distinction between "combustibles" and "supporters of combustion." For a while I let this pass.

bodies? Name some kinds of attraction. Is this force cohesion? Why not? Is it adhesion? Why not?" I finally tell them the force is called *chemical attraction*, and I call on them to put into words a clear definition of chemical attraction. As they do so, I simply criticise the successive trials they make, until the definition is correct in matter and form; and then, after making them repeat it several times in concert, I write it on the blackboard.

By similar questions, which I will not weary the reader by repeating, I make them draw from the same experiment facts and definitions about elements, simple substances, compounds, oxides, decomposition, etc., etc.

In my life, I have taught a great deal of Latin and English, but I know no such language-lesson as is given when a class, under the fire of a skillful teacher's criticism, slowly perfects a clear logical statement, or definition, for which they have gained the material by using their own senses and reason. My pupils keep note-books, and at every lesson bring me, neatly written out, the substance of the previous lesson.

I have given above only a sample of the general tenor of questions. Sometimes some misapprehension on the part of pupils makes me diverge widely to bring them back on the track.

I endeavor to make the subject as practical as possible by having pupils study the chemistry of common operations. After the above experiment, I usually introduce the subject of *air* by asking: "Why did the taper at last fail to light again when dipped into the jar? What had become of the oxygen in the jar? Did the remains of the burned paper look like the remains when paper is burned in the air?"

After this I take a bit of sodium and burn it in oxygen. I also oxidize some in the air. I show, by testing, that the oxygen has disappeared from the jar. I test the first oxide with red litmus, both before and after dissolving in water. I let the pupils taste a little of a very dilute solution. I then ask questions about sodium just as I did about oxygen and mercury. I ask what has become of the oxygen and the sodium; what unites them; what the force is called; draw them on to classify the result of the union as a compound and an oxide; draw them on to note the properties of the compound. Then I have them test the oxide formed in the air just as the other was tested. I ask: "Is this a compound? Do you think you know either of its elements? Of which one are you sure? Do you think you know the other element? Why do you think it is oxygen? Where did the oxygen come from? What other reason have you for thinking the air contains oxygen?"

I wait for further experiments before indorsing their partly formed conclusion about oxygen in the air. We next make some study of carbon by burning coal in oxygen. I have them test the result with lime-water. We burn coal in a receiver of air, and test this result also. I have some powdered charcoal heated in contact with the red oxide

of mercury, and that result tested. Every particle of information which observation can draw from these experiments is carefully elicited by questions such as I have described.

At this point I usually inform them that the red oxide of mercury is sometimes made by heating mercury a long time in contact with air. They commonly by this time consider the evidence of oxygen in the air pretty conclusive. I next lead them to think about the air we breathe: whether it comes from our lungs unchanged; to think of some way of testing whether it contains free oxygen. I have them test the breath with lime-water, discuss the effect of the union of carbon and oxygen, especially the heat.

In all this I tell them very little. I become greatly interested in seeing how much I can get them to do for themselves. I simply try to stimulate and get them on the right track. At this point I usually ask them whether they think the air contains anything besides oxygen, and set them to discussing ways of getting at the other element in air.

Devising experiments is a very important part of chemical training, and, where the pupil sees beforehand some question to settle, he can be made to do it. By rousing him to think, criticising his crude plan, and showing, or making him think of, its defects, it can be done. Pupils will devise the well-known experiment of burning away oxygen from air, but of course they must be told that phosphorus is the best combustible for their purpose. By taking up the various requirements of the experiment separately, they will suggest nearly everything.

But before the experiment is actually carried out, to prevent the confusion which would arise from the vapor of phosphoric anhydride, I have them make a little study of phosphorus. It is examined, burned in oxygen, burned in air, the anhydride noted, its great affinity for water, its behavior to litmus both before and after union with water, its taste noted, etc. After this we use phosphorus to help us study the composition of air. The girls note (approximately) the proportion of oxygen to nitrogen.

We test the air for carbonic acid; discuss the moisture in it, etc.; and then I have them make some study of water. To do this I first put a bit of sodium in a very small cage of wire gauze, and thrust it under a little water. The result is tested, and shown to be the same compound they before knew. When they are satisfied that the oxygen must come from the water, we collect hydrogen and examine it. I have them also note the new method of decomposition. Then we have the proof by synthesis, burning hydrogen and collecting a little of the water.

As we proceed, my pupils begin to think ahead of questions, and their perceptions grow sharper.*

* In final review, I employ the topical method of recitation, but this method is too loose for *investigation*, which must be held down to accuracy, by well-considered questions, taking up one point at a time.

If, after this, we decompose water by a battery, the students will at once recognize the process for themselves as decomposition; and it confirms their previous analysis of water. But, if I begin experimenting by battery decomposition, they can not study out for themselves the rationale of the process. Of course, the teacher can explain and point out and make it understood, but they take it all pretty much upon authority, and their minds are far less active and independent. And so, of making oxygen at first with potassium chlorate. The chlorate is a less simple substance than the red oxide of mercury; and the presence of the binoxide of manganese, with the catalysis, complicates the process.

While directing this experimental study I do not tell them any of the facts which come on testimony, unless, like the fact about the making of the red oxide of mercury, it is a necessary step in some chain of reasoning which they can make out mainly for themselves.

The precautions necessary in using such substances as sodium make it unwise and imprudent to set careless young folks to handling them. One accident would bring lasting disrepute on our chemical study.

Showy experiments are demoralizing, though they excite for the time a sensational interest. But, when young folks really think for themselves, they are so pleased with it that they can take the highest interest in a very simple process. There is an experiment which I learned from that capital book, "Eliot and Storer's Chemistry," which illustrates a good many things I have said. It is designed to show the great diffusibility of hydrogen. A tube, closed at one end with plaster of Paris, is filled with hydrogen, and put in a tumbler of water for a day or two. The water first rises in the tube, then sinks to the level of that in the tumbler, in consequence of hydrogen escaping faster than air comes in. When I first taught chemistry, my pupils took no interest in this experiment. When I tried making them discuss the changes, and discover for themselves the property of hydrogen which causes them (which they do with all ease), they find it more interesting than the burning of phosphorus in oxygen. This experiment shows, too, how genuine inductive teaching must necessarily be oral teaching, for a text-book merely *tells* the philosophy of the changes, which is precisely the thing the pupils ought not to be told.

When chemistry is taught inductively, the order in which the subject is presented becomes important. It is of the highest consequence that the more dependent parts of the science should not be put forward in the beginning. I do not think the order of our American text-books so good as that of Stockhardt.

I will state, in a very few words, the order which seems to me best. I usually make the pupil study, first, the individual properties of the thirty chief elements, taking up no compounds but oxides and hydrogen acids. The pupil should test the oxides with red or blue litmus; note the acid or basic taste; note which are insoluble in water. The

difference between hydrates and anhydrides should be clearly brought out, and the part which hydrogen plays. After this survey, the pupil, for himself, without prompting, divides the elements into their two great classes.

Then, after some little study of sulphides and the other binary compounds, the principal acids and bases should be shown in their concentrated form. After this, a number of them should be combined to form salts, and, in doing this, it should be brought out very clearly (*by*, not *for* the pupil) how the bases replace the hydrogen of the acid. There should also be some general study of crystallization.

It would be easy to multiply suggestions, but it has been my purpose in this brief paper simply to describe what I have tried, and give only the results of experience.

A NEW THEORY OF THE SUN.

THE CONSERVATION OF SOLAR ENERGY.

By C. WILLIAM SIEMENS.

A PAPER was recently read by me before the Royal Society, under the above title, which may be termed a first attempt to open for the sun a creditor and debtor account, inasmuch as he has hitherto been regarded only as the great almoner, pouring forth incessantly his boundless wealth of heat, without receiving any of it back. Such a proposal touches the root of solar physics, and can not therefore be expected to pass without challenge—to meet which I gladly embrace the opportunity, now offered to me through the courtesy of the editor of this review, of enlarging somewhat upon the first concise statement of my views regarding this question.

Man has from the very earliest ages looked up with a feeling of awe and wonderment to our great luminary, to whom we owe not only the light of day, but the genial warmth by which we live, by which our hills are clad with verdure, our rivers flow, and without which our life-sustaining food, both vegetable and animal, could not be produced.

When for our comfort and our use we resort to a fire either of wood or coal, we know now by the light of modern science that we are utilizing only solar rays that have been stored up by the aid of the process of vegetation in our forests or in the forests of former geological ages, when our coal-fields were the scenes of rank tropical growth. The potency of the solar ray in this respect was recognized—even before science had discovered its true significance—by clear-sighted men such as the late George Stephenson, who, when asked what in his opin-

ion was the ultimate cause of the motion of his locomotive-engine, said that he thought it went by "the bottled-up rays of the sun."

With the exception of our coal-fields and a few elementary combustible substances such as sulphur and what are called the precious metals, which we find sparsely scattered about, our earth consists essentially of combined matter. Thus our rivers, lakes, and oceans are filled with oxidized hydrogen, the result of a most powerful combustion; and the crust of our earth is found to consist either of quartz (a combination of the metal silicon with oxygen) or limestone (oxidized calcium combined with oxidized carbon), or of other metals, such as magnesium, aluminium, or iron, oxidized and combined in a similar manner. Excepting, therefore, the few substances before enumerated, we may look upon our earth, near its surface at any rate, as a huge ball of cinder, which, if left to itself, would soon become intensely cold, and devoid of life or animation of any kind.

It is true that a goodly store of heat still exists in the interior of our earth, which, according to some geologists, is in a state of fusion, and must certainly be in a highly heated condition; but this internal heat would be of no avail, owing to the slow rate of conduction, by which alone, excepting volcanic action, it could be brought to us living upon its surface.

An estimate of the amount of heat poured down annually upon the surface of our earth may be formed from the fact that it exceeds a million times the heat producible by all the coal raised, which may be taken at 280,000,000 tons a year.

If, then, we depend upon solar radiation for our very existence from day to day, it can not be said that we are only remotely interested in solar physics, and the question whether and how solar energy, comprising the rays of heat, of light, and the actinic rays, is likely to be maintained, is one in which we have at least as great a reversionary interest as we have in landed estate or other property.

If the amount of heat, or, more correctly speaking, of energy, supplied annually to our earth is great as compared with terrestrial quantities, that scattered abroad in all directions by the sun strikes us as something almost beyond conception.

The amount of heat radiated from the sun has been approximately computed by the aid of the pyrheliometer of Pouillet, and by the actinometers of Herschel, at 18,000,000 heat-units from every square foot of its surface per hour; or, expressed popularly, if coal were consumed on the surface of the sun in the most perfect manner, our total annual production of 280,000,000 tons, being the estimated produce of all the coal-mines of the earth, would suffice to keep up solar radiation for only one forty-millionth part of a second; or, if the earth were a mass of coal, and could be supplied by contract to the solar furnacemen, this supply would last them just thirty-six hours.

If the sun were surrounded by a solid sphere of a radius equal to

the mean distance of the sun from the earth (95,000,000 miles), the whole of this prodigious amount of heat would be intercepted; but considering that the earth's apparent diameter as seen from the sun is only seventeen seconds, the earth can intercept only the 2,250-millionth part. Assuming that the other planetary bodies swell the amount of intercepted heat to ten times this amount, there remains the important fact that $\frac{2249999999}{2250000000}$ of the solar energy is radiated into space, and apparently lost to the solar system, and only $\frac{1}{2250000000}$ utilized or intercepted.

Notwithstanding this enormous loss of heat, solar temperature has not diminished sensibly for centuries, if we neglect the periodic changes, apparently connected with the appearance of sun-spots, that have been observed by Lockyer and others, and the question forces itself upon us, how this great loss can be sustained without producing an observable diminution of solar temperature, even within a human life-time.

Among the ingenious hypotheses intended to account for a continuance of solar heat is that of shrinkage or gradual reduction of the sun's volume, suggested by Helmholtz. It may, however, be argued against this theory that the heat so produced would be liberated throughout its mass, and would have to be brought to the surface by conduction, aided perhaps by convection; but we know of no material of sufficient conductivity to transmit anything approaching the amount of heat lost by radiation.

Chemical action between the constituent parts of the sun has also been suggested; but here again we are met by the difficulty that the products of such combination would, ere this, have accumulated on the surface, and would have formed a barrier against further action.

These difficulties led Sir William Thomson to the suggestion that the cause of maintenance of solar temperature might be found in the circumstance of meteorites, not falling upon the sun from great distances in space, as had been suggested by Mayer and Waterton, but circulating with an acquired velocity within the planetary distances of the sun, and he shows that each pound of matter so imported would represent a large number of heat-units, without disturbing the planetary equilibrium. But in considering more fully the enormous amount of planetary matter that would be required for the maintenance of the solar temperature, Sir William Thomson soon abandoned this hypothesis for that of simple transfer of heat from the interior of a fluid sun to the surface by means of convection-currents, which latter hypothesis is at the present time supported by Professor Stokes and other leading physicists.

This theory has certainly the advantage of accounting for the greatest possible store of heat within the solar mass, because it supposes the latter to consist in the main of a fluid heated to such a temperature that, if it were relieved at any point of the confining pressure,

it would flash into gas of a vastly inferior, but still of an elevated, temperature. It is supposed that such fluid material, or material in the "critical" condition, as Professor Thomas Andrews, of Belfast, has named it, is continually transferred to the surface by means of convection-currents, that is to say, by currents forming naturally when a fluid substance is cooled at its upper surface, and sinks down after cooling to make room for ascending material at the comparatively higher temperature. It is owing to such convection-currents that the temperature of a room is, generally speaking, higher toward the ceiling than toward the floor, and that upon plunging a thermometer into a tank of heated water the surface temperature is found slightly superior to that near the bottom.

These convection-currents owe their existence to a preponderance of the cooled descending over the ascending current; but this difference being slight, and the ascending and descending currents intermixing freely, they are, generally speaking, of a sluggish character; hence, in all heating apparatus, it is found essential to resort either to artificial propulsion, or to separating walls between the ascending and the descending currents, in order to give effect to the convective transfer of heat.

In the case of a fluid sun another difficulty presents itself through the circumstance that the vast liquid interior is enveloped in a gaseous atmosphere, which, although perhaps some thousands of miles in depth, represents a relatively very small store of heat. Convection-currents may be supposed active in both the gaseous atmosphere and in the fluid ocean below, but the surface of this fluid must necessarily constitute a barrier between the two convective systems, nor could the convective action of the gaseous atmosphere—that is to say, the simple up and down currents caused by surface refrigeration—be such as to disturb the liquid surface below to any great extent, because each descending current would have had plenty of time to get intermixed with its neighboring ascending current, and would, therefore, have reached its least intensity on arriving on the liquid surface.

As regards the liquid, its most favorable condition for heating purposes would be at the critical point, or that at which the slightest diminution of superincumbent pressure would make it flash off into gas; but considering that, by means of conduction and convection, the liquid matter must have assumed, in the course of ages, a practically uniform temperature to a very considerable depth, it follows that the liquid below the surface, with fluid pressure in addition to that of the superimposed gaseous atmosphere, must be ordinary fluid, the critical condition being essentially confined only to the surface.

Conditions analogous to those here contemplated are met with in a high-pressure steam-boiler, with its heated water and dense vapor atmosphere. Suppose the fire below such a boiler be withdrawn, and its roof be exposed to active radiation into space, what should we ob-

serve through a strong pane of glass inserted in the side of the boiler near the liquid surface, lit up by an incandescent electric lamp within? The loss of heat by radiation from the boiler would give rise to convection-currents, and partial condensation of the vapor atmosphere; then, if the motion of the water were made visible by means of coloring matter, we should observe convection-currents in the fluid mass separate and distinct from those in the gaseous mass; but these convection-currents would cause no visible disturbance of the liquid surface, which would present itself to the eye with the smoothness of a mirror. It is only in the event of the steam-pressure being suddenly relieved at any point on the surface that a portion of the water would flash into steam, causing a violent upheaval of the liquid.

The dark spots on the sun appear to indicate commotion of this description, but these are evidently not the result of mere convection-currents; if they were, they would occur indiscriminately over the entire surface of the sun, whereas telescopic observation has revealed the fact that they do occur almost exclusively in two belts, between the equator and the polar surfaces on either side. Their occurrence could be satisfactorily explained if we could suppose the existence of strong lateral currents flowing from the polar surfaces toward the equator, which lateral currents in the solar atmosphere would cause cyclones or vortex action with a lower and denser atmosphere consisting probably of metallic vapors; this vortex action extending downward would relieve the fluid ocean locally from pressure, and give rise to explosive outbursts of enormous magnitude, projecting the lower atmosphere high above the photosphere, with a velocity measured, according to Lockyer, by a thousand miles a second. It will be seen from what follows how, according to my views, such vortex action in those intermediate regions of the sun would necessarily be produced.

But supposing that, notwithstanding the difficulties just pointed out, convection-currrents sufficed to effect a transfer of internal heat to the surface with sufficient rapidity to account for the enormous surface-loss by radiation, we should only have the poor satisfaction of knowing that the available store would last longer than might have been expected, whereas a complete solution of the problem would be furnished by a theory, according to which the radiant energy which is now supposed to be dissipated into space and irrecoverably lost to our solar system, could be arrested and brought back in another form to the sun himself, there to continue the work of solar radiation.

Some six years ago the thought occurred to me that such a solution of the solar problem might not lie beyond the bounds of possibility, and, although I can not claim intimate acquaintance with the intricacies of solar physics, I have watched its progress, and have engaged also in some physical experiments bearing upon the question, all of which have served to strengthen my confidence, and to ripen in me

the determination to submit my views, not without some misgiving, to the touchstone of scientific criticism.

For the purposes of my theory, stellar space is supposed to be filled with highly rarefied gaseous bodies, including hydrogen, oxygen, nitrogen, carbon, and their compounds, besides solid materials in the form of dust. Each planetary body would in that case attract to itself an atmosphere depending for density upon its relative attractive importance, and it would not seem unreasonable to suppose that the heavier and less diffusible gases would form the staple of these local atmospheres; that, in fact, they would consist mostly of nitrogen, oxygen, and carbonic acid, while hydrogen and its compounds would predominate in space.

In support of this view it may be urged that, in following out the molecular theory of gases as laid down by Clausius, Clerk Maxwell, and Thomson, it would be difficult to assign a limit to a gaseous atmosphere in space; and, further, that some writers—among whom I will here mention only Grove, Humboldt, Zöllner, and Mattieu Williams—have boldly asserted the existence of a space filled with matter. But Newton himself, as Dr. Sterry Hunt tells us in an interesting paper which has only just reached me, has expressed views in favor of such an assumption.

The history of Newton's paper is remarkable and very suggestive. It was read before the Royal Society on the 9th and 16th of December, 1675, and remained unpublished until 1757, when it was printed by Birch, the then secretary, in the third volume of his "History of the Royal Society," but received no attention; in 1846 it was published in the "Philosophical Magazine" at the suggestion of Harcourt, but was again disregarded; and now, once more, only a few months since, a philosopher on the other side of the Atlantic brings back to the birthplace of Newton his forgotten and almost despised work of two hundred years ago.

Quoting from Dr. Sterry Hunt's paper:

Newton in his Hypothesis imagines "an ethereal medium much of the same constitution with air, but far rarer, subtler, and more elastic. . . . But it is not to be supposed that this medium is one uniform matter, but composed partly of the main phlegmatic body of ether, partly of other various ethereal spirits, much after the manner that air is compounded of the phlegmatic body of air intermixed with various vapors and exhalations." Newton further suggests in his Hypothesis that this complex spirit or ether, which, by its elasticity, is extended throughout all space, is in continual movement and interchange. "For Nature is a perpetual circulatory worker, generating fluids out of solids, and solids out fluids; fixed things out of volatile, and volatile out of fixed; subtile out of gross, and gross out of subtile; some things to ascend and make the upper terrestrial juices, rivers, and the atmosphere, and by consequence others to descend for a requital to the former. And as the earth, so perhaps may the sun imbibe this spirit copiously, to conserve his shining, and keep the planets from receding further from him; and they that will may also suppose that this spirit affords or

carries with it thither the solary fuel and material principle of life, and that the vast ethereal spaces between us and the stars are for a sufficient repository for this food of the sun and planets. . . . Thus, perhaps, may all things be originated from ether."

If at the time of Newton chemistry had been understood as it now is, and if, moreover, he had been armed with that most wonderful of all modern scientific instruments, the spectroscope, the direct outcome of his own prismatic analysis, there appears to be no doubt that the author of the laws of gravitation would have so developed his thoughts upon solar fuel that they would have taken the form rather of a scientific discovery than of a mere speculation.

Our proof that interstellar space is filled with attenuated matter does not rest, however, solely upon the uncertain ground of speculation. We receive occasionally upon our earth celestial visitors termed meteorites; these are known to travel in loose masses round the sun in orbits intersecting at certain points that of our earth. When in their transit they pass through the denser portion of our atmosphere they become incandescent, and are popularly known as falling stars. In some cases they are really deserving of that name, because they strike down upon our earth, from the surface of which they have been picked up and subjected to searching examination while still warm after their exertion. Dr. Flight has only very recently communicated to the Royal Society an analysis of the occluded gases of one of these meteorites as follows:

CO_2 (Carbonic acid)	0·12
CO (Carbonic oxide)	31·88
H (Hydrogen)	45·79
CH_4 (Marsh-gas)	4·55
N (Nitrogen)	17·66
	100·00

It appears surprising that there was no aqueous vapor, considering that there was much hydrogen and oxygen in combination with carbon; but perhaps the vapor escaped observation, or was expelled to a greater extent than the other gases by external heat when the meteorite passed through our atmosphere. Opinions concur that the gases found occluded in meteorites can not be supposed to have entered into their composition during the very short period of traversing our denser atmosphere; but, if any doubt should exist on this head, it ought to be set at rest by the fact that the gas principally occluded is hydrogen, which is not contained in our atmosphere in any appreciable quantity.

Further proof of the fact that stellar space is filled with gaseous matter is furnished by spectrum analysis, and it appears from recent investigation, by Dr. Huggins and others, that the nucleus of a comet contains very much the same gases found occluded in meteorites, in-

cluding "carbon, hydrogen, nitrogen, and probably oxygen," while, according to the views set forth by Dewar and Liveing, it also contains nitrogenous compounds such as cyanogen.

Adversely to the assumption that interplanetary space is filled with gases, it is urged that the presence of ordinary matter would cause sensible retardation of planetary motion, such as must have made itself felt before this; but, assuming that the matter filling space is an almost perfect fluid not limited by border surfaces, it can be shown on purely mechanical grounds that the retardation by friction through such an attenuated medium would be very slight indeed, even at planetary velocities.

But it may be contended that, if the views here advocated regarding the distribution of gases were true, the sun should draw to himself the bulk of the least diffusible, and therefore the heaviest gases, such as carbonic acid, carbonic oxide, oxygen, and nitrogen, whereas spectrum analysis has proved, on the contrary, a great prevalence of hydrogen.

In explanation of this seeming anomaly, it can be shown, in the first place, that the temperature of the sun is so high that such compound gases as carbonic acid and carbonic oxide could not exist within him, their point of dissociation being very much below the solar temperature. It has been contended, indeed, by Mr. Lockyer, that none of the metalloids have any existence at these temperatures, although as regards oxygen Dr. Draper asserts its existence in the solar photosphere. There must be regions, however, outside that thermal limit, where their existence would not be jeopardized by heat; and here great accumulation of the comparatively heavy gases that constitute our atmosphere would probably take place, were it not for a certain counterbalancing action.

I here approach a point of primary importance in my argument, upon the proof of which my further conclusions must depend.

The sun completes one revolution on its axis in twenty-five days, and its diameter being taken at 882,000 miles, it follows that the tangential velocity amounts to 1·25 miles per second, or to what the tangential velocity of our earth would be if it occupied five hours instead of twenty-four in accomplishing one revolution. This high rotative velocity of the sun must cause an equatorial rise of the solar atmosphere, to which Mairan, in 1731, attributed the appearance of zodiacal light. Laplace rejected this explanation on the ground that zodiacal light extended to a distance from the sun exceeding our own, whereas the equatorial rise of the solar atmosphere due to its rotation could not exceed nine twentieths of the distance of Mercury. But it must be remembered that Laplace based his calculation upon the generally accepted hypothesis of an empty stellar space (occupied only by an imaginary ether), and it can be shown that the result of solar rotation would be widely different, if supposed to take place

within a medium of unbounded extension. In this case pressures would be balanced all round, and the sun would act mechanically upon the floating matter surrounding him in the manner of a fan, drawing it toward himself upon the polar surfaces, and projecting it outward in a continuous disk-like stream from the equatorial surfaces.

By this fan action, hydrogen, hydrocarbons, and oxygen are supposed to be drawn in enormous quantities toward the polar surfaces of the sun ; during their gradual approach they pass from their condition of extreme attenuation and intense cold to that of compression, accompanied with increase of temperature, until, on approaching the photosphere, they burst into flame, giving rise to a great development of heat, and a temperature commensurate with their point of dissociation at the solar density. The result of their combustion will be aqueous vapor and carbonic acid, and these products of combustion, in yielding to the influence of centrifugal force, will flow toward the solar equator, and be thence projected into space.

In view of the importance of this centrifugal action for the purpose of my theory, the following simple mathematical statement of the problem may not be thought out of place : Let us consider the condition of two equal gaseous masses, at equal distances from the solar center, the one in the direction of the equator, the other in that of either of the poles. These two masses would be equally attracted toward the sun, and balance one another as regards the force of gravitation, but the former would be subject to another force, that of centrifugal action, which, however small in amount as compared with the enormous attraction of the sun, would destroy the balance, and determine a motion toward the sun as regards the mass opposite the polar surface, and into space as regards the equatorial mass. The same action would take effect upon the masses filling their places, and the result must be a continuous current depending for its velocity upon the rate of solar rotation. The equatorial current so produced, owing to its mighty proportions, would flow outward into space, to a practically unlimited distance.

The next question for consideration is, What would become of these products of combustion when thus returned into space? Apparently they would gradually change the condition of stellar material, rendering it more and more neutral ; but I venture to suggest the possibility, nay, the probability, that solar radiation will, under these conditions, step in to bring back the combined materials to a state of separation by dissociation carried into effect at the expense of that solar energy which is now supposed to be irrevocably lost or dissipated into space as the phrase goes.

According to the law of dissociation as developed by Bunsen and Sainte-Claire Deville, the point of decomposition of different compounds depends upon the temperature on the one hand, and upon the pressure on the other. According to Sainte-Claire Deville, the disso-

ciation tension of aqueous vapor at atmospheric pressure and at 2,800° C. is 0·5, that is to say one half of the vapor would exist as such, the remaining half being found as a mechanical mixture of hydrogen and oxygen; but, with the pressure, the temperature of dissociation rises and falls, as the temperature of saturated steam rises and falls with its pressure. It is therefore conceivable that the solar photosphere may be raised by combustion to a temperature exceeding 2,800° C., whereas dissociation may be effected in space at a lower temperature. This temperature of 2,800° would be quite sufficient to account for the character and amount of solar radiation, if it is only borne in mind that the luminous atmosphere may be a thousand miles in depth, and that the flame of hydrogen and hydrocarbons, in the uppermost layers of this zone, is transparent to the radiant energy produced in the layers below, thus making the total radiation rather the sum of matter in combustion than the effect of a very intensely heated surface.

Sainte-Claire Deville's investigations had reference only to heats measured by means of pyrometers, but do not extend to the effects of radiant heat. Dr. Tyndall has shown by his important researches that vapor of water and other gaseous compounds intercept radiant heat in a most remarkable degree, and there is other evidence to show that radiant energy from a source of high intensity possesses a dissociating power far surpassing the measurable temperature to which the compound substance under its influence is raised. Thus carbonic acid and water are dissociated in the leaf-cells of plants under the influence of the direct solar ray at ordinary summer temperature, and experiments in which I have been engaged for nearly three years * go to prove that this dissociating action is obtained also under the radiant influence of the electric arc, although it is scarcely perceptible if the energy is such as can be produced by an inferior source of heat.

The point of dissociation of aqueous vapor and carbonic acid admits, however, of being determined by direct experiment. It engaged my attention some years ago, but I have hesitated to publish the qualitative results I then obtained, in the hope of attaining to quantitative proofs.

These experiments consisted in the employment of glass tubes furnished with platinum electrodes, and filled with aqueous vapor or with carbonic acid in the usual manner, the latter being furnished with caustic soda to regulate the vapor-pressure by heating. Upon immersing one end of the tube charged with aqueous vapor in a refrigerating mixture of ice and chloride of calcium, its temperature at that end was reduced to −32° C., corresponding to a vapor-pressure, according to Regnault, of $\frac{1}{1800}$ of an atmosphere. When so cooled no slow electric discharge took place on connecting the two electrodes with a small

* See "Proceedings, Royal Society," vol. xxx, March 1, 1880; also a paper read before Section A of the British Association, September 1, 1881, and ordered to be printed in the report.

induction-coil. I then exposed the end of the tube projecting out of the freezing mixture, backed by white paper, to solar radiation (on a clear summer's day) for several hours, when, upon again connecting up to the inductorium, a discharge, apparently that of a hydrogen vacuum, was obtained. This experiment being repeated furnished unmistakable evidence, I thought, that aqueous vapor had been dissociated by exposure to solar radiation. The carbonic-acid tubes gave, however, less unmistakable effects. Not satisfied with these qualitative results, I made arrangements to collect the permanent gases so produced by means of a Sprengel pump, but was prevented by lack of time from pursuing the inquiry, which I propose, however, to resume shortly, being of opinion that, independently of my present speculation, the experiments may prove useful in extending our knowledge regarding the laws of dissociation.

It should be here observed that, according to Professor Stokes, the ultra-violet rays are in large measure absorbed in passing through clear glass, and it follows from this discovery that only a small portion of the chemical rays found their way through the tubes to accomplish the work of dissociation. This circumstance being adverse to the experiment only serves to increase the value of the effect observed, while it appears to furnish additional proof of the fact, first enunciated by Professor Draper, and corroborated by my own experiments on plants, that the dissociating power of light is not confined to the ultra-violet rays, but depends in the process of vegetation chiefly upon the yellow and red rays.

Assuming, for my present purpose, that dissociation of aqueous vapor was really effected in the experiment just described, and assuming, further, that stellar space is filled with aqueous and other vapor of a density not exceeding the $\frac{1}{2000}$ part of our atmosphere, it seems reasonable to suppose that its dissociation would be effected by solar radiation, and that solar energy would thus be utilized. The conjoint presence of aqueous vapor, carbonic acid, and nitrogen would only serve to facilitate their decomposition, in consequence of the simultaneous formation of hydrocarbons and nitrogenous compounds by combination of the nascent hydrogen and the nitrogen with carbon in a manner analogous to what occurs in vegetation. It is not necessary to suppose that all the energy radiated from the sun into space should be intercepted, inasmuch as even a partial return of heat in the manner described would serve to supplement solar radiation, the balance being made up by absolute loss. To this loss of energy would have to be added that consumed in sustaining the circulating current, which however, need not relatively be more than what is known to be lost on our earth through the tidal action, and may be supposed to be compensated as regards the time of solar rotation by gradual shrinkage.

By means of the fan-like action resulting from the rotation of the sun, the vapors dissociated in space to-day would be drawn toward the

polar surfaces of the sun to-morrow, be heated by increase in density, and would burst into flame at a point where both their density and temperature had reached the necessary elevation to induce combustion, each complete cycle taking, however, years to be accomplished. The resulting aqueous vapor, carbonic acid, and carbonic oxide would be drawn toward the equatorial regions, and be then again projected into space by centrifugal force.

Space would, according to these views, be filled with gaseous compounds in process of decomposition by solar radiant energy, and the existence of these gases would furnish an explanation of the solar absorption spectrum, in which the lines of some of the substances may be entirely neutralized and lost to observation. As regards the heavy metallic vapors revealed in the sun by the spectroscope, it is assumed that these form a lower and denser solar atmosphere, not participating in the fan-like action which is supposed to affect the light outer atmosphere only, in which hydrogen is the principal factor.

Such a dense metallic atmosphere could not participate in the fan action affecting the lighter photosphere, because this is only feasible on the supposition that the density of the inflowing current is, at equal distances from the gravitating center, equal or nearly equal to the outflowing current. It is true that the products of combustion of hydrogen and hydrocarbon are denser than their constituents, but this difference may be balanced by their superior temperature on leaving the sun, whereas the metallic vapors would be unbalanced, and would therefore obey the laws of gravitation, recalling them to the sun. On the surface of contact between the two solar atmospheres, intermixture induced by friction must take place, however, giving rise to those vortices and explosive effects within the zones of the sun, between the equator and the polar surfaces, to which reference has already been made in this article; these may appropriately be called the "stormy regions" of the sun, which were first observed and commented upon by Sir John Herschel. Some of the denser vapors would probably get intermixed, be carried away mechanically by the lighter gases, and give rise to that cosmic dust observed to fall upon our earth in not inappreciable quantities, and generally assumed hitherto to be the *débris* of broken meteorolites. Excessive intermixture between the heat-producing atmosphere and the metallic vapors below appears to be prevented by the existence of an intermediate neutral atmosphere, and called the penumbra.

As the whole solar system moves through space at a pace estimated at 150,000,000 miles annually (being about one fourth of the velocity of the earth in its orbit), it appears possible that the condition of the gaseous fuel supplying the sun may vary according to its state of previous decomposition, in which other heavenly bodies may have taken part, and whereby an interesting reflex action between our sun and other heavenly bodies would be brought about. May it not be

owing to such differences in the quality of the fuel supplied that the observed variations of the solar heat may arise?—and may it not be in consequence of such changes in the thermal condition of the photosphere that the extraordinary convulsions revealed to us as sun-spots occur?

The views here advocated could not be thought acceptable unless they furnished at any rate a consistent explanation of the still somewhat mysterious phenomena of the zodiacal light and of comets. Regarding the former, we should be able to revert to Mairan's views, the objection by Laplace being met by a continuous outward flow from the solar equator. Luminosity would be attributable to particles of dust emitting light reflected from the sun, or to phosphorescence. But there is another cause for luminosity of these particles, which may deserve serious consideration. Each particle would be electrified by gaseous friction in its acceleration, and its electric tension would be vastly increased in its forcible removal, in the same way as the fine dust of the desert has been observed by Dr. Werner Siemens to be in a state of high electrification on the apex of the Cheops Pyramid. Could not the zodiacal light also be attributed to slow electric discharge backward from the dust toward the sun?—and would not the same cause account for a great difference of potential between the sun and earth, which latter may be supposed to be washed by the solar radial current? May not the presence of the radial solar current also furnish us with an explanation of the fact that hydrogen, while abounding apparently in space, is practically absent in our atmosphere, where aqueous vapor and carbonic acid, which would come to us directly from the sun, take its place? An action analogous to this, though on a much smaller scale, may be set up also by terrestrial rotation, giving rise to an electrical discharge from the outgoing equatorial stream to the polar regions, where the atmosphere to be pierced by the return flood is of least resistance. Thus the phenomenon of the aurora borealis or northern lights would find an easy explanation.

The effect of this continuous outpour of solar materials could not be without very important influences as regards the geological conditions of our earth. Geologists have long acknowledged the difficulty of accounting for the amount of carbonic acid that must have been in our atmosphere, at one time or another, in order to form with lime those enormous beds of dolomite and limestone, of which the crust of our earth is in great measure composed. It has been calculated that, if this carbonic acid had been at one and the same time in our atmosphere, it would have caused an elastic pressure fifty times that of our present atmosphere; and, if we add the carbonic acid that must have been absorbed in vegetation in order to form our coal-beds, we should probably have to double that pressure. Animal life, of which we find abundant traces in these "measures," could not have existed under such conditions, and we are almost forced to the conclu-

sion that the carbonic acid must have been derived from an external source.

It appears to me that the theory here advocated furnishes a feasible solution of this geological difficulty. Our earth being situated in the outflowing current of the solar products of combustion, or, as it were, in the solar chimney, would be fed from day to day with its quota of carbonic acid, of which our local atmosphere would assimilate as much as would be necessary to maintain it in a carbonic-acid vapor density balancing that of the solar current; we should thus receive our daily supply of this important constituent (with the regularity of fresh rolls for breakfast), which, according to an investigation by M. Reiset, communicated to the French Academy of Sciences by M. Dumas on the 6th of March last, amounts to the constant factor of one ten-thousandth part of our atmosphere. The aqueous vapor in the air would be similarly maintained as to its density, and its influx to, or reflux from, our atmosphere would be determined by the surface temperature of our earth.

It is also important to show how the phenomena of comets could be harmonized with the views here advocated, and I venture to hope that these occasional visitors will serve to furnish us with positive evidence in my favor. Astronomical physicists tell us that the nucleus of a comet consists of an aggregation of stones similar to meteorites. Adopting this view, and assuming that the stones have absorbed in stellar space gases to the amount of six times their volume, taken at atmospheric pressure, what, it may be asked, will be the effect of such a divided mass advancing toward the sun at a velocity reaching in perihelion the prodigious rate of 366 miles per second (as observed in the comet of 1845), being twenty-three times our orbital rate of motion? It appears evident that the entry of such a mass into a comparatively dense atmosphere must be accompanied by a rise of temperature by frictional resistance, aided by attractive condensation. At a certain point the increase of temperature must cause ignition, and the heat thus produced must drive out the occluded gases, which in an atmosphere 3,000 times less dense than that of our earth would produce $6 \times 3{,}000 = 18{,}000$ times the volume of the stones themselves. These gases would issue forth in all directions, but would remain unobserved except in that of motion, in which they would meet the interplanetary atmosphere with the compound velocity, and form a zone of intense combustion, such as Dr. Huggins has lately observed to surround the one side of the nucleus, evidently the side of forward motion. The nucleus would thus emit original light, whereas the tail may be supposed to consist of stellar dust rendered luminous by reflex action produced by the light of the sun and comet combined, as foreshadowed already by Tyndall, Tait, and others, starting each from different assumptions.

Although I can not pretend to an intimate acquaintance with the

more intricate phenomena of solar physics, I have long had a conviction, derived principally from familiarity with some of the terrestrial effects of heat, that the prodigious dissipation of solar heat is unnecessary to satisfy accepted principles regarding the conservation of energy, but that solar heat may be arrested and returned over and over again to the sun, in a manner somewhat analogous to the action of the heat recuperator in the regenerative engine and gas-furnace. The fundamental conditions are :

1. That aqueous vapor and carbon compounds are present in stellar or interplanetary space.

2. That these gaseous compounds are capable of being dissociated by radiant solar energy while in a state of extreme attenuation.

3. That the vapors so dissociated are drawn toward the sun in consequence of solar rotation, are flashed into flame in the photosphere, and rendered back into space in the condition of products of combustion.

Three weeks have now elapsed since I ventured to submit these propositions to the Royal Society for scientific criticism, and it will probably interest my readers to know what has been the nature of that criticism and the weight of additional evidence for or against my theory.

Criticism has been pronounced by mathematicians and physicists, but affecting singularly enough the chemical and not the mathematical portion of my argument; whereas chemists have expressed doubts regarding my mathematics while accepting the chemistry involved in my reasoning.

Doubts have been expressed as to the sufficiency of the proof that dissociation of attenuated aqueous vapor and carbonic acid is really effected by radiant solar energy, and, if so effected, whether the amount of heat so supplied to the sun could be at all adequate in amount to keep up the known rate of radiation. It was admitted in my paper that my own experiments on the dissociation of vapors within vacuous tubes amounted to inferential rather than absolute proof ; but the amount of inferential evidence in favor of my views has been very much strengthened since by chemical evidence received from various sources ; and I will here only refer to one of these.

Professor Piazzi Smyth, the Astronomer Royal for Scotland, has, in connection with Professor Herschel, of Newcastle, recently presented an elaborate paper or series of papers to the Royal Society of Edinburgh "On the Gaseous Spectra in Vacuum-Tubes," of which he has kindly forwarded me a copy. It appears from these memoirs that when vacuum-tubes, which contain attenuated vapors, have been laid aside for a length of time, they turn practically into hydrogen-tubes. In another very recent paper presented to the Royal Society of Edinburgh, Professor Piazzi Smyth furnishes important additional proof of the presence of oxygen in the outer solar atmosphere, and gives an ex-

planation why this important element has escaped observation by the spectroscope. Additional proof of the existence of oxygen in the outer solar atmosphere has been given by Professor Stoney, the Astronomer Royal for Ireland, and by Mr. R. Meldola in an interesting paper communicated by him to the "Philosophical Magazine," in June, 1878.

As regards the sufficiency of an inflowing stream of dissociated vapors to maintain solar energy, the following simple calculation may be of service: Let it be assumed that the stream flowing in upon the polar surfaces of the sun flashes into flame when it has attained the density of our atmosphere, that its velocity at that time is 100 feet per second (the velocity of a strong terrestrial wind), and that in its composition only one twentieth part is hydrogen and marsh-gas in equal proportions, the other nineteen twentieths being made up of oxygen, nitrogen, and neutral compounds. It is well known that each pound of hydrogen develops in burning about 60,000 heat-units, and each pound of marsh-gas about 24,000; the average of the two gases mixed in equal proportion would yield, roughly speaking, 42,000 units; but, considering that only one twentieth part of the inflowing current is assumed to consist of such combustible matter, the amount of heat developed per pound of inflowing current would be only 2,100 heat-units. One hundred cubic feet, weighing eight pounds, would enter into combustion every second upon each square foot of the polar surface, and would yield $8 \times 60 \times 60 \times 2{,}100 = 60{,}480{,}000$ heat-units per hour. Assuming that one third of the entire solar surface may be regarded as polar heat-receiving surface, this would give 20,000,000 heat-units per square foot of solar surface; whereas, according to Herschel's and Pouillet's measurements, only 18,000,000 heat-units per square foot of solar surface are radiated away. There would thus be no difficulty in accounting for the maintenance of solar energy from the supposed source of supply. On the other hand, I wish to guard myself against the assumption that appears to have been made by some critics, that what I have advocated would amount to the counterpart of "perpetual motion," and therefore to an absurdity. The sun can not of course get back any heat radiated by himself which has been turned to a purpose; thus the solar heat spent upon our earth in effecting vegetation must be absolutely lost to him.

My paper presented to the Royal Society was accompanied by a diagram of an ideal corona, representing an accumulation of igneous matter upon the solar surfaces, surrounded by disturbed regions pierced by occasional vortices and outbursts of metallic vapors, and culminating in two outward streams projecting from the equatorial surfaces into space through many thousands of miles. The only supporting evidence in favor of this diagram were certain indications that may be found in the instructive volume on the sun by Mr. R. A. Proctor. It was therefore a matter of great satisfaction to me to be informed, as I have been by an excellent authority and eye-witness,

that my imaginary diagram bore a very close resemblance to the corona observed in America on the occasion of the total eclipse of the sun on the 11th of January, 1880.

Enough has been said, I think, to prove that the theory I have ventured to put forward is the result, at any rate, of considerable reflection; and I may add that, since its first announcement, I have not seen reason to reject any of the links of my chain of argument: these I have here endeavored to strengthen only by additional facts and explanations.

If these arguments can be proved to the entire satisfaction of those best able to form a judgment, they would serve to justify the poet Addison when he says:

> "The unwearied sun from day to day
> Does the Creator's power display,
> And publishes to every land
> The work of an Almighty Hand."
>
> —*Nineteenth Century.*

THE FUTURE OF MIND.*

By PETER BRYCE, M. D.

BUT what does science testify as to the probable future of mind in earthly life? Have mind and body attained their supreme development? Is humanity a fixed entity, incapable of essential modifications or improvement? All the evidence goes to show that the improvement of the human race is practically illimitable. This is true both of mind and body, which, as has been shown, advance *pari passu*, and is made very evident by the fact that the pre-eminence of Europeans over barbarous races, which is so manifest in their intellect, is just as manifest in their anatomy and physiology. There is a diversity of proofs of the advance of the physical man in modern times. No one questions that the average duration of life is being steadily prolonged. Besides a multitude of new arts and new sciences, all the arts and sciences known to the ancients have been so wondrously developed as to seem like new creations of the modern man. Geology, zoölogy, botany, chemistry, geography—physical and political—medicine, painting, politics, theology, etc.—every department, in fact, of human interest—have grown, as it were, into new and marvelous revelations. But to suppose that these immense developments of art and science can have resulted without corresponding improvements in the human intellect, is to ignore very important biological principles.

* From a discourse on "Some of the Phenomena of Mind," delivered before the Medical Association of the State of Alabama, April 11, 1882, by Dr. Peter Bryce, Superintendent of the Alabama Insane Hospital, etc.

As an advanced science implies an advanced art—the progress of the two being ever conditioned upon each other—so the great advances of the sciences and arts imply a corresponding development of human intelligence. The principle of action and reaction prevails in the world of mind as in the world of matter, and while the human intellect, by cogent applications of its powers, has established multitudinous differentiations in things once inextricably intermingled, a corresponding differentiation and specialization of its own powers has inevitably resulted. But specialization of functions being the direct evidence of its greater perfection, it is incontrovertible that the multiplication of specializations of knowledge by human inquiry has resulted in improvements of the powers of the human mind. The strain now put on human power to keep pace with the advances already made is an assurance that there will be in the future no lack of occasion for continued mental development. All departments of human enterprise have in truth been already so marvelously developed as to defy the complete grasp of any but specialists of more than ordinary capacity. Croakers may find fault and stigmatize the advance of the age as mainly material. Never did carping criticism have poorer ground for its averments. The material advance is fully matched by the moral advance. Proofs of it are so multiplied as scarcely to deserve enumeration. Liberty to think boldly and to give free utterance to honest convictions is fast becoming a sacred principle of society. Liberty of person, and equal justice—irrespective of rank and wealth—are now almost everywhere recognized as divinest principles of government. The sick and the unfortunate, instead of being left to die without aid or to pine through a miserable existence, are now everywhere provided for at the expense of those whom fortune has subjected to less severe trials. Sumptuary laws are now not only known to be useless but their principle is condemned. Private war has almost ceased to be waged; and the duty of revenge, once sanctioned by religion, has given place to the duty of forbearance and forgiveness. The well-being of one's neighbor is now universally felt to be the good fortune of one's self. Vast accumulations of wealth, instead of being squandered in the purchase of places and useless decorations for elevating one's self above his fellows, are now employed in educational, industrial, and eleemosynary foundations.

Nor is this true of individuals only. Governments, both monarchical and republican, instead of employing their resources in war and destruction, are now rivals in the most beneficent achievements for prolonging and ennobling human life. Slavery has been abolished in nearly every civilized country, and all forms of privileged oppression are rapidly meeting with the same condemnation. In truth, such has been the progress of morals and the general assimilation of the principles of equity, that the most important functions of life and society are now accomplished without the intervention of government,

giving promise of a gradual declension of the functions of the central power before the more precise and equitable supervision of society constituted of individuals imbued with ever-present aspirations for justice and advancement. Already this day of a new excellence has dawned, and there are not a few indications that new crystallizations of social forces are destined to supervene. The liberation of woman from her ancient servitude and her rapid advance to every privilege for which her powers adapt her, the emancipation of children from the severe domestic tyrannies and cruelties to which they were time out of mind subjected, are striking evidences of the ameliorations due to general moral advance. Like the animal organism the social organism responds throughout its whole substance to any force brought to bear upon it, and the influence of scientific methods of thought is destined to exert upon society augmenting influences of the most pervading and salutary kinds. Truth and morality are inextricably intermingled, and whatever aids in the discovery of truth is a potential moral adjuvant. As, in Scripture, condemnation and the belief in lies are everywhere conjoined, so moral advance is ever assured by devices that accomplish the enlargement of the realm of truth. To carp at scientific methods is to carp at truth, for scientific methods are only severe procedures for the discovery of truth; and there is, to my mind, little doubt that in no great while the much-desired reconciliation of natural with revealed truth will be successfully achieved. I find in late utterances of scientific men of the highest stamp much that is in conformity with some of the prevalent teachings of religion. Herbert Spencer is unquestionably the most perfect embodiment of advanced scientific thought. While in special departments there are many that go before him, in the power of co-ordinating the various sciences and embodying their myriad diverse facts into a consistent body of philosophy he goes far before all his contemporaries. His writings, indeed, stand apart as a great mountain-range looming far above the lesser heights. It would be easy, from Mr. Spencer's writings, to accumulate declarations that have wondrous congruity with orthodox doctrine. The worship of humanity, Mr. Spencer declares, can never take the place of the worship of God. He also affirms, with all our orthodox creeds, that precepts of right living do little or no good unless the corresponding emotion can in some way be roused. His standard of right conduct, scientifically deduced, is a perfect law of righteousness which may not be debased below the mark of perfection, however unable men and women may be to fulfill its requirements.

In every aspect, therefore, the prospect of human advancement is very cheering. Individually and collectively man is so steadily progressing to the achievement of the great problem of his life—perfect conformity to the conditions of his being—that no mad enthusiasm is needful to prompt the anticipation of a rapid advance to that condition

of things which the ancient seers foresaw and aspired toward, when "they shall beat their swords into plowshares, and their spears into pruning-hooks: nation shall not lift up the sword against nation, neither shall they learn war any more."

But, while science is disclosing the methods of mind, and preparing for it on earth a nobler and still more noble *rôle*, what are its testimonies as to the duration of mind—its immortality? Some of the most devoted adherents of scientific methods have reached conclusions which are unfavorable to mind's immortality. But it is not surprising, in view of the novelty and marvelousness of many lately demonstrated scientific truths, that even men of calm temper should be led to attach undue importance to them—to claim for them reaches and meanings which do not of right belong to them. Close as may be the demonstrated union between mind and body, no philosophy of organization and life satisfactorily accounts for the presence of mind. Mind is indeed unique, peculiar; has its own laws, and overleaps and undermines all mere material phenomena. The study of mind is, therefore, incomplete unless subjectively pursued. The mind must be questioned, must testify of itself, if we would arrive at anything approaching just conclusions with reference to it. This is indisputable from the fact that mind is that mysterious quality in us by which we explore all material phenomena. It is only, therefore, by due attention to mind's subjective contemplation that we gain the right to reason upon the phenomena of material things. A surveyor who should go around determining boundaries, directions, and areas, without having first put to severe tests his compass and chains, would be acting not a whit more absurdly than they who leave out of the study of material and mental phenomena a subjective study of mind. But, if only by questioning mind about itself we can rightly understand its nature, dare we, in conducting the inquiry, ignore a whole host of its most prominent intuitions? Surely not. But mind's testimony of itself is, that there are in it indefeasible principles of individuality, responsibility, and immortality. It would be strange, indeed, if this noble, this intensely royal, thing, which disdains to be classed with any material forces, however sublimated they may be, should be remanded to the companionship and fate of the phenomenal, the sensual, the perishing!

Happily for the theory of evolution, not all nor even the majority of its advocates have given assent to such conclusions. Mr. Darwin has ever conjoined with his marvelous disclosures of the relations of organic facts a spirit of religious reverence. Mr. Herbert Spencer avows that there are unseen, eternal verities which justify religion. Lessing, David Strauss, and Professor Helmholtz, could not reconcile themselves to the thought of a final destruction of the living race, and, with it, all the fruits of all past generations. Others among them, however, assume that, since mind is only known to us as a phenomenon

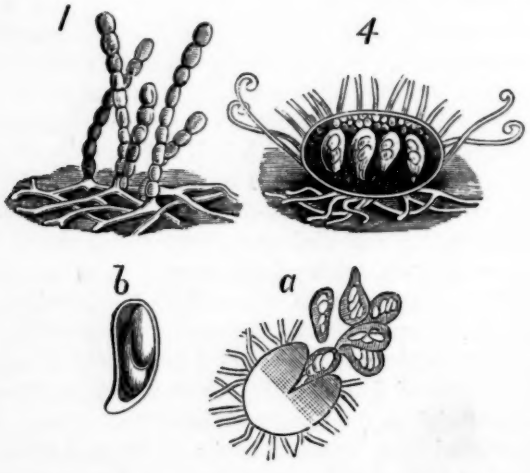
of organism, the death of the organism involves a discontinuance of all its functions—thought, affection, and will, not excepted—and their resolution into the more primitive forces from which they originally sprang. But it is clearly a most unwarranted assumption that spiritual individuality—the fundamental principle of which no one pretends to apprehend—can not be prolonged or perpetuated, except under such material circumstances as earth supplies. If it be recollected how ignorant man is of the essences of matter and motion, and that there are in mind or spirit qualities which can not be ranged with material things, or with their almost infinitely subtile forces, we will readily see that the assumption of no conscious life except under such circumstances as material things supply is most unwarrantable.

Even the argument against immortality, based upon the relations of mind to organism, when closely examined, loses much of its seeming fitness. The persistence of force is, indeed, as much an axiom of science as the indestructibility of matter. What appears to be cessation of force is simply its transformation into other forces. But muscular movements provoked by volition are not actuated by mental force. The mind, in voluntary motions, does not supply the force. It only signals the nerve-centers that furnish the force. The centers of motion, which have of late been demonstrated in the brain, do not supply the force for the operation of the muscles, whose contractions they specially control. The brain-centers are properly only intellectual signal-centers—centers whence issue the volitions that liberate the forces of the lower nerve-centers for contracting special muscles. Fatal errors in reference to mind may easily grow from confounding nervous force with mental force. It is impossible to form right conceptions of mind so long as it is regarded as a merely resultant force made up of the organic forces which lead up to it. In any such conception there is left out an important element which it is difficult explicitly to define, but which may be forcibly suggested by a comparison. The beautiful form—symmetry and proportions—of a noble tree may be regarded apart from the organic materials and forces which underlie it. Thus regarded it is, as it were, spiritual, and is capable of arousing conceptions of beauty and grandeur in the soul of the beholder. Mind, in this view, instead of a mere force, becomes a symmetrical and living expression of the relations of the myriad forces which have from the very beginning entered into the life. It is, therefore, in one view, as absolutely immaterial as the form and beauty of a tree. But in still another aspect mind must be considered a higher and vastly more subtile force than any physical forces with which we are acquainted, and in its actions and methods of development is governed by laws peculiarly its own. Mind or mental force is, therefore, unique, and stands apart as a grand exception to the general law of the correlation of forces. But, as all the physical forces are persistent in some form or other, it is eminently unreasonable to suppose that this peculiar force,

that immeasurably transcends all others, should alone undergo absolute extinction. It needs must be, therefore, that mind or mental force shall continue to exist after dissolution of the organism with which its manifestations are associated, by passing into a new state, or new conditions of activity, of which science takes no cognizance. Thus considered, mind, in its ultimate analysis, becomes a purely spiritual entity which can never be dissolved and commingled with the heterogeneous forces of the material world.

ABOUT THE MOLDS.

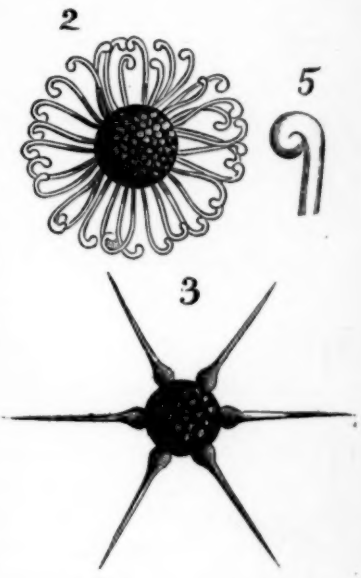
THE molds represent an immense variety of minute plants that grow upon a great number of objects, and under different circumstances. The spores from which they are developed are borne in the air, imperceptibly to us because of their extreme littleness. The microscopic examination of them reveals some very curious dispositions and forms, always worthy of admiration. We often, in the spring, perceive blades of grass covered with a chalk-like dust, so white that one is at first sight inclined to take it to be hoar-frost. On examining it with a microscope of small power, we shall perceive a real forest of



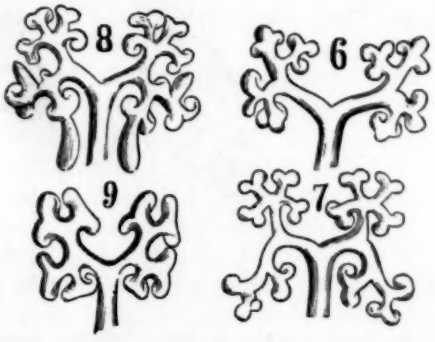
minute plants. Little bundles of very delicate filaments, clear and crystalline, composed of roundish cells connected together, rise from a net-work of other branching filaments, which are collectively called the *mycelium* (Fig. 1). These curious organisms are the first phases of a parasitic plant belonging to the great order of the cryptogams, or a

fungus. A mold that has caused great damage to grape-vines—the *Oidium Tuckeri*—is an incompletely developed fungus.

A whitish substance may be remarked on the leaves of lilacs near the middle of the summer, which might be regarded on superficial observation as dust from the road. It is also a mold. The microscope shows it to be made up of very delicate threads, similar to those of spiders' webs. As these threads become older, we may observe joined to them a number of little spheroidal bodies, some very small and white, others larger and yellow, and others brown. The white and yellow corpuscles are young fruits of the fungus, and the brown ones are ripened fruits. If one of the last is put into a drop of water and pressed between two glasses for mounting microscopic preparations, it will let escape some small pyriform, transparent sacs, each inclosing spores, the number of which varies according to the species, but is definite for each species. The arrangement of these spore-containing sacs (*sporangiæ*) is shown by the vertical section (Fig. 4). The number of *sporàngiæ* (*b*) contained in each of the fruits varies in different species from one to twenty and more.



Aside from every scientific consideration, a great interest is given to these plants by the beauty of their ornamentation; and they form



choice objects for preparations. Around each receptacle may be seen numerous appendages radiating in every direction, and generally uncolored. In some genera these appendages are long and flaky, while other genera have only six or eight of them in the form of short needles

projecting from a bulbous base (Fig. 3). The extremities of the needles in other species are curved and turned over, as in Figs. 2 and 5, and in others they are one or two times branched; while in the genus *Microsphœria* the extremities of the appendages take the most varied and most exquisite forms (Figs. 6, 7, 8, and 9).

The life and history of these little plants afford a large field for studies and investigations, which are within the reach of every one who has a good microscope, and is not engaged on any other special study. Such researches are, moreover, of great practical value. The parasitic fungi are one of the great plagues of agriculture. They fix themselves in hosts upon leaves and fruits, where they shut up the stomata and prevent the action of air and light. The hope of discovering a remedy for such evils is dependent on the study of their causes.

THE INTRODUCTION OF DOMESTIC ANIMALS.*

THE roving shepherd sows hastily a piece of land, which he leaves after harvesting his crop, to do the same the next year with another piece of land. But, when fruit-growing is combined with agriculture, this unsettled shepherd-life becomes entirely changed. The plantation of trees and vines must be inclosed, and taken care of a long time before it will bring fruit. Hence arises the sense of a settled home and of individual possession. Even the house of the planter becomes a firmer structure; the ground is more thoroughly cultivated, so that a smaller territory suffices to support the family, and individuals combine more and more into social communities. Man thus becomes accustomed to a settled order of life, and to the relations which form the foundation of lawful constitutions. Closely associated with these changes in the mode of living is the introduction of domestic animals.

In the early time, when the tribes of the Indo-European people still formed one undivided folk in its Asiatic home, the sheep and the cow had already been tamed. This is proved in the case of the sheep by the numerous varieties existing among them. The word *daughter*, which means "the milker," and which is common to all the Indo-European languages, bears witness to the early taming of the cow. Of both these animals, man at first used only the milk, the flesh, and the skin. Afterward the cow became man's assistant in agriculture. It was not until a much later time that the horse took the place of the cow, at first chiefly in traveling and in riding, afterward more and more in agricultural operations. Here, however, arises the important question, whether the people already possessed these tamed animals

* Translated from the German.

when they moved into the several parts of Europe, or were they first received by them at a later time.

There is no doubt that the original home of the horse is not Europe, but Central Asia; for since the horse in its natural state depends upon grass for its nourishment and fleetness for its weapon, it could not in the beginning have thriven and multiplied in the thick forest-grown territory of Europe. Much rather should its place of propagation be sought in those steppes where it still roams about in a wild state. Here, too, arose the first nations of riders of which we have historic knowledge, the Mongolians and the Turks, whose existence even at this day is as it were combined with that of the horse. From these regions the horse spread in all directions, especially into the steppes of Southern and Southeastern Russia and into Thrace, until it finally found entrance into the other parts of Europe, but not until *after the immigration of the people.* This assumption is, at least, strongly favored by the fact that the farther a district of Europe is from those Asiatic steppes, i. e., from the original home of the horse, the later does the tamed horse seem to have made its historic appearance in it. The supposition is further confirmed by the fact that horse-raising among almost every tribe appears as an art derived from neighboring tribes in the East or Northeast. Even in Homer the ox appears exclusively as the draught-animal in land operations at home and in the field, while the horse was used for purposes of war only. Its employment in military operations was determined by swiftness alone. That the value of the horse must originally have depended on its fleetness, can easily be inferred from the name which is repeated in all the branches of the Indo-European language, and signifies nearly "hastening," "quick." The same fact is exemplified by the descriptions of the oldest poets, who, next to its courage, speak most of its swiftness. How beautiful, for example, is the description in Homer!—

> ". . . As when some courser, fed
> With barley in the stall, and wont to bathe
> In some smooth-flowing river, having snapped
> His halter, gayly scampers o'er the plain,
> And in the pride of beauty bears aloft
> His head and gives his tossing mane to stream
> Upon his shoulders, while his flying feet
> Bear him to where the mares are wont to graze."
>
> *Iliad* (Bryant's translation, vi, 644–651).

And what lofty words does the author of the book of Job use in speaking of this animal!—

> "He mocketh at fear, and is not affrighted;
> Neither turneth he back from the sword.
> The quiver rattleth against him,
> The glittering spear and the shield.

He swalloweth the ground with fierceness and rage:
Neither believeth he that it is the sound of the trumpet.
He saith among the trumpets, Ha, ha;
And he smelleth the battle afar off, the thunder of the captains, and the shouting."

(Chapter xxxix, verses 22–25.)

It was chiefly by reason of these two properties—fleetness and courage—that the horse quickly became an animal without which history would seem barren enough. Without the horse neither the expeditions of an Alexander, nor a migration of tribes, nor a Christian knighthood, would have been possible; in a word, without the horse, all those mighty movements which have shaken the world and have stirred the very foundations thereof, could never have been thought of; and the people, sitting still and silent upon the ground, would never have left their accustomed boundaries to go forth fighting and colonizing from land to land.

Happily the horse possessed still other important properties which rendered possible its employment in other than warlike uses. Chief among these properties are its sagacity, endurance, and fidelity. When, therefore, war was no longer the chief employment of Europeans, and agriculture had taken its place, man soon thought of employing the horse as a draught-animal as he in like manner had hitherto used the cow. Then did the horse become, for the first time, of real use to culture, and a leading actor in it. Such had not been the case in Asia up to this time. The ox had drawn the plow and wagon but lazily and slowly, and agriculture had made slow progress; but with the horse came a new impulse, a higher purpose in this occupation, which made it an important and valuable one. Even to this time the horse, by reason of his excellent properties, is regarded as the truest companion and aid of man in all the operations as well of war as of agriculture. Neither is this noble animal to be forgotten in commerce and trade, nor in art; in a word, it is the most valuable and therefore the best treated domestic animal which Europe has to exhibit.

Besides the horse, some other animals, which in the pastoral time had not yet entered Europe, soon made their appearance. They were the ass, with its near relative the mule, and the goat. All these wandered, as did the vine, fig, and olive, from Asia Minor and Syria to Greece; and, strange as it may seem, the mule preceded the ass, whose original home may after all have to be sought for in Africa. Both spread at a later date from Greece into the same regions in which the vine and the olive found their way, and for a time did not pass beyond these regions. For, notwithstanding their patience and contentment, by virtue of which they are satisfied with the most wretched food, they did not find the climate in Northern Europe a hospitable one for them, and are both still really strangers there.

The goat, too, on account of its predilection for young trees, buds, and sharp, aromatic herbs, can be kept in great numbers only in those regions in which the injuries inflicted by them are of relatively little importance. It therefore feels more at home in the rocky labyrinths of the Grecian islands, Sicily, Sardinia, and Italy, than in the northern regions. According to the census, Italy in 1863 possessed forty-one million goats.

Of four-footed animals, Europe has received only one further addition—the cat. Unlike the dog, it was most probably not a primitive companion of man, but is relatively a late gain. The taming of the animal is a fruit of the religious customs of the Egyptians, who recognized the worth of this mouse-destroyer, and permitted divine honors to be paid to it. Its picture, therefore, meets us beside other wonderful figures upon numerous Egyptian monuments, and in the tombs whole layers of cat-mummies are sometimes to be found.

The ancient Greeks were not acquainted with the cat, but the mouse was certainly known to them from the earliest period—a fact shown by the name which is common to all the Indo-European languages, and which signifies apparently "thief"—and they not seldom suffered so severely under the plague of these pests that whole regions were devastated and in consequence had to be abandoned. For the destruction of the mice they used either the weasel or the marten, which were tamed for this purpose. The weasel, especially, held just the same place among them that the cat now holds among us, and it passed in like manner into proverbs and fables. In Aristophanes, a certain person is summoned to tell a story, and he begins his fable with the words—

"There was once a mouse and a weasel."

That the cat was as little known as a domestic animal to the Romans as it was to the Greeks, is plainly shown by the story of the country and the city mouse, as narrated by Horace, who lived in the time of Augustus. There is certainly no question that if Horace had known the cat he would have mentioned it in this passage, but no mention of it is made. In the fourth century A. D., we find the cat mentioned for the first time among the domestic animals, and it not only spread abroad among all the European peoples, but was also transplanted to Asia. If Hehn's conjecture be correct, its general introduction was occasioned by the irruption of the rat, which seems to have entered Europe in company with the immigrants from Asia.

Among the Germans this animal was allotted to Freya, whose carriage was drawn by two cats. At the same time it was regarded as a shrewd, magic-working animal, and it therefore played a leading part in matters of witchcraft, during the middle ages, beside the owl and the bat, in myths that grew plainly enough out of its sneaking movement, its preference for the night, its dark fur, and its eyes, which glow in the dark. Cats guarded secret treasures in mountains and

caves, they lay at cross-roads, at night they carried on their operations in ruined mills in the forest; even witches and magicians assumed their forms in order either to inflict injury upon others or to visit the Blocksberg. The German fables of animals allot to the cat the prize for wisdom and deception. When it becomes necessary to bring the robber Reynard to court to make an end to all his evil deeds and the complaints arising therefrom, and Brown, i. e. Bruin, the bear has failed in the attempt, then it appears that only Harry, the cat, is able to accomplish the task of delivering the artful message to the evil-doer. Again, the cat does not lack certain desirable qualities. How burdensome does the dog with its caresses often become, how unskillfully does he exert himself to please; how gentle and amiable, on the contrary, can the cat be, how pleasant its manner and motion! During the middle ages, therefore, the cat served as a plaything for distinguished ladies, who nursed it on their laps and fed it with dainty bits; and at the present time, among many persons, the cat finds recognition and love: in Gottfried Mind it has found its Raphael, and poets, like Tieck, Amadeus Hoffman, Lichtwer, and in recent times Scheffel, have ennobled their thinking and striving; who, for example, does not hold in grateful remembrance the deep philosophizing of the cat Hidigeigei (in Scheffel's "Trompeter von Säkkingen") on the theme "Why do men kiss?" Even Lessing's quaint nature could find a source of enjoyment in this animal; on his writing-table lay his cat, and no one can read without emotion how Lessing, when his favorite had destroyed the manuscript of "Nathan," patiently and quietly wrote the poem anew without depriving the author of the mischief of its usual place. Notwithstanding this, for most men there is something demoniacal and weird about the animal, which withdraws it from their sympathy; hence Massius rightly says of it, "Complicated by the favor of parties and by their hate, its character in history wavers."

Among manifold other varieties of animals, birds have always excited in a marked degree the attention and the favor of man. Since the primeval time hosts of songs have been sung to the lark, the stork, the nightingale, and the swallow, and the speech of people greets them in their flight with a thousand fond, familiar words. Nay, it is not too much to assert that, without the birds, even the spring-time would be sad, just as by their flight the winter becomes so much the more gloomy and desolate. But that which most attracts us to birds is their power of song and of flight. In ancient times favored men pretended to understand their mysterious sounds, which were to them the voice of Fate, since they seemed either to encourage by a cheerful address or to warn by threatening tones. The flight especially seemed to be supernatural and worthy of admiration, and there has certainly been no lack of attempts to imitate it, as the myth of the Greeks regarding Dædalus and Icarus shows. But it was precisely

this power of flight, and the impulse to wander connected therewith, which made it impossible for man to draw the majority of fowls into closer relations with himself, and to make them useful to him. He was in reality able to domesticate only those which had lost more or less the power to fly, or those which had in only a slight degree the character of flying animals, and were not compelled to change their dwelling-place in winter. Thus our presentation is limited to the few which are now regarded as really domestic animals—viz., to the goose, duck, turkey, and peacock.

Although the taming of the goose and the duck reaches back to a very early period—since neither of them was brought hither from Asia, but both are descended from our native wild varieties—the fowl, or chicken, is of comparatively recent date in Europe. In the Old Testament, and upon the Egyptian monuments, it is not to be found. It appeared first in India, and gradually spread farther westward, where it gained much respect, especially among the Persians. In the religion of Zoroaster the cock was sacred, being regarded as the herald of the morning and a symbol of light, because he drove away the evil spirits of darkness.

In Homer and Hesiod, and in general in the oldest Greek poets, we find no trace of the fowl. It seems to have been first mentioned by Theognis (about 600 B. C.), and was universally known to the contemporaries of the Persian War. The comparison between the fights of cocks and of men is a favorite one with the poets of that period.

Themistocles is said to have once stirred the courage of his army by pointing to two fighting cocks which staked their lives for the glory of victory, and not for their hearths and gods. It agrees well with its late introduction that the cock has attained to but little importance in cultivated circles: he was sacred to Ares (Mars), and people were accustomed, after recovery from sickness, to bring to Æsculapius, the god of medicine, a cock as a sacrifice.

From Greece the fowl quickly found its way into Sicily and Lower Italy; only the Sybarites, who were notorious gluttons, are said to have admitted no fowl within their walls, so that they might not be disturbed in their sleep.

Among the Romans the fowl played a very important part: sacred cocks accompanied the departing commanders to the scene of war, and were used for taking the auspices. It was considered a favorable sign if the fowls ate greedily; but, on the other hand, it denoted a misfortune if they refused food. It will thus be readily seen that the attendant of these birds (*pullarius*) exercised much influence in this matter, according as he did, or did not, give the fowls food before the taking of the augury.

How widely the breeding of fowls spread and developed in Italy may be learned from the writings of Varro and of Columella. Fowls, and especially fighting-cocks, were constantly imported from places

which had become noted for breeding them—e. g., Rhodes, Chalcis, Delos—or directly from Persia.

That the fowl did not come into Germany from Italy, but that a more direct transfer of it from Persia—perhaps by way of Thrace, Illyria, and Pannonia—must have taken place, is shown by the names (*hahn, huhn, henne*), which are independent of, and different from, the Greek and Latin names; and it is further shown by the ideas and representations which, in the North, are connected with the fowl. Thus we find in separate and distinct places the same belief as in Persia—that the cock, by his crowing, frightens away the evil spirits; he was the symbol of flame, the animal of Loki, the god of fire: when he unfolded his wings, conflagrations started up under him, whence comes the still current expression for an act of incendiarism, "To set the red cock upon any one's roof." Cæsar reports of the Britons that among them, just as among the Persians, no one was allowed to eat the flesh of fowls. At what time, however, the northern immigration took place can not be accurately stated; yet the supposition can not be wide of the truth that it was when the Persians, during their expeditions to Greece, came into contact with the above-named tribes—somewhere about the fifth century B. C. From that starting-point, then, this useful domestic animal soon spread abroad everywhere, and found always the most ready reception wherever man was about to change from a nomadic shepherd-life and have a settled, permanent home. At present the breeding of fowls receives most attention in France, which country is said to support, at the lowest calculation, 100,000,000 fowls—a striking example of what an important part in the economical life of a people this animal is capable of playing.

The peacock, too, is a native of Asia, having come to us from India. Phœnician ships, so early as the time of Solomon, brought it to the coast of the Mediterranean Sea. The first place in which peacocks were kept in Greece seems to have been the temple of Hera in Samos, for there, according to mythology, this bird had its origin. That the peacock was dedicated to Hera can not astonish us, for she is the goddess of the starry heaven. Another myth related that the thousand-eyed Argus, the watcher of the moon goddess Io, had been slain by Apollo and changed into a peacock, or that Hera had placed his thousand eyes upon the feathers of her bird. Moreover, the peacock was very profitable for that temple of Hera, inasmuch as its plumage enticed thither many inquisitive sight-seers, who willingly paid the temple tribute for a sight of the beautiful bird. As a reward for this, the Samians placed its image upon their coins.

In Athens we find the peacock first mentioned in the fifth century B. C., and the contemporary writers fail to find sufficient words to tell what a surprise its appearance had made among that inquisitive and novelty-loving people. It is, therefore, not remarkable that, already in the fourth century B. C., peacocks were more numerous in Athens than quail.

The question, "By what way and by whom was the peacock brought into Italy?" is shrouded in deep darkness; and the supposition of Hehn, that it was brought thither directly from Phœnicia or Carthage, stands upon doubtful testimony. It was, however, cordially received and prized in that country, especially in the later times of senseless luxury. The orator Hortensius, a contemporary of Cicero, was the first to bring the peacock roasted upon the table, and, despite the lack of palatableness in its flesh, his example seems to have been extensively imitated.

From Italy the peacock found its way into the rest of Europe, and became in Christian lands the subject of a double symbol. On one side it was regarded as an emblem of immortality, for the story gained credence that its flesh was incorruptible; on the other hand, it served as an exhortation to humility, according to the well-known proverb, "The peacock has a brilliant coat of feathers, but do not look down at its feet."

Reference was made, too, to its sneaking walk and its vicious character, especially in old age. But the knight gladly adorned his helmet with its feathers, and the custom at great banquets of bringing to the table, amid the flourish of trumpets, a roasted peacock adorned with its own feathers, and of taking a vow thereupon, lasted down to the end of the middle ages. In more recent times, however, the bird, together with its flesh and its feathers, has fallen into discredit; and it is left to the Chinese mandarin to carry the peacock's feathers as a sign of rank.

HYDRODYNAMICS AND ELECTRICITY.

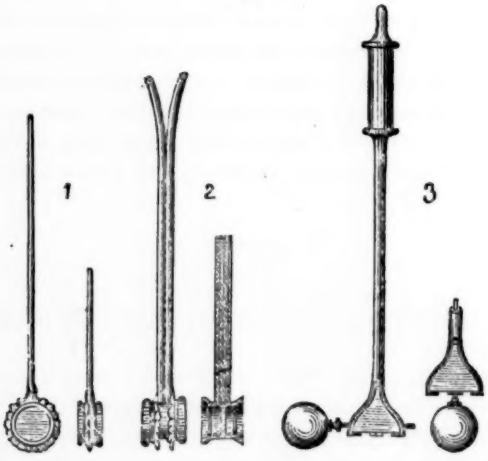
VISITORS at the recent Electrical Exposition in Paris were much interested in an apparatus exhibited by Dr. C. A. Bjerknes, of the University of Christiania, Norway, for the illustration of certain properties in hydrodynamics analogous to some of the manifestations of electricity and magnetism. Professor Bjerknes has been carrying on his investigations in this line for nearly twenty years, having published his first paper, "On the Internal Condition of an Incompressible Fluid in which a Sphere of Variable Volume is moving," in 1863, and having followed it up with numerous other papers relating to similar problems. The results of experiments in every case corresponded with those which had previously been indicated to him by mathematical calculations. The experiments had in view the study of molecular movements by reproducing mechanically, but in the inverse sense, as the results proved, the simple and fundamental electrical and magnetic phenomena.

Pulsating and oscillating bodies are applied so as to produce vibra-

tions in a trough of water about six inches deep. By pulsating bodies are meant those which undergo alternate changes of volume, marked by two distinct phases, one of swelling and one of contraction. The pulsations of the two bodies are spoken of as synchronous when the similar phases occur simultaneously in them. The oscillating bodies are constant in volume, but undergo alternate changes of place, from right to left and from left to right, or in a vertical direction.

Pulsations are communicated by means of little tambours or drums made of hollow cylinders of metal, over the ends of which are stretched flexible plates or membranes. These drums are made to swell and contract by means of pumps, with which they are connected by India-rubber tubing, that compress the air within them. Two drums are usually employed in the experiments, each connected with a separate pump, so that the rhythm of the pulsations may be regulated at will. Thus both drums may be caused to pulsate synchronously, or with an opposite rhythm. In the simplest pulsator (Fig. 1, 1) the two drum-

FIG. 1.



heads beat synchronously, or suffer dilatation and collapse together, as the pump is worked. In another disposition the drum-heads are separated by a rigid partition dividing the instrument into two chambers, each having its separate connection by a distinct tube, with a different pump, making it practicable to produce either synchronous or unsynchronous pulsations. A more common disposition is to use two simple pulsators in connection with the two pumps, one of which is held in the hand, while the other is mounted in the water, so as to be left free to move.

The two phases of pulsation are regarded by Professor Bjerknes as analogous to the poles of the electrode or magnet. The phase of dilatation may thus be likened to the north pole, that of collapse to the south

pole. If, now, having one of the drums mounted in the water, and the other held in the hand, we bring them near each other while both are dilating or both are contracting—that is, while both are in the same phase of pulsation—attraction will take place between them. The mounted drum will assume the direction of approach toward the one held in the hand, and of following it when it is removed; but if they are in opposite phases—if one is swelling while the other is contracting—they will be repelled. Like poles attract, unlike ones repel. The phenomena are the inverse of what are observed in ordinary electricity and magnetism, where unlike poles attract and like ones repel. The pulsating drum in these experiments represents an isolated pole, a conception which physicists have not hitherto regarded as possible.

Spheres of invariable volume, but adjusted so as to oscillate in either an horizontal or vertical direction, may be used instead of the pulsating drums, when the phenomena assume a modified shape. The oscillators used by Professor Bjerknes are mounted as in the figure (Fig. 1, 3), where the sphere on the left is arranged so as to oscillate horizontally, and the one on the right to oscillate vertically, the alternate movements of oscillation being produced, like the pulsations of the drums, by alternately forcing in and withdrawing the air. The opposite sides of the sphere assume opposite phases, and the sphere acts like a magnet. If a sphere is brought near a pulsator, so that its oscillating movement shall be toward the drum while that is dilating, attraction takes place; but, if it be turned in the opposite direction, so as to be moving away from the drum while the same is swelling, repulsion will be manifested.

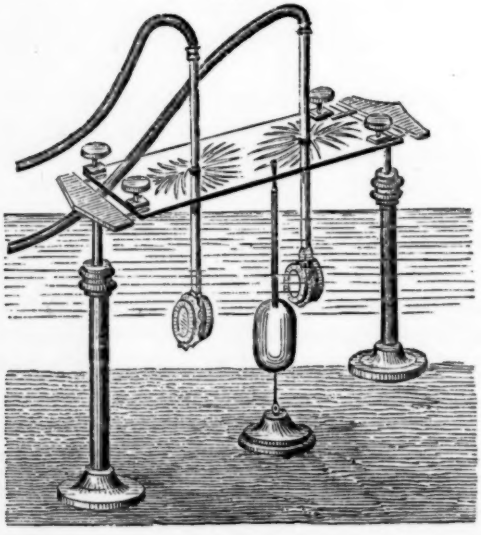
If two oscillating spheres be brought near each other, attraction takes place in case they are both moving to or from each other; repulsion, in case they are both moving in the same direction: and the change can be effected at once, as before, by turning one of the spheres around.

Professor Bjerknes has a considerable variety of apparatus for modifying the aspects of the phenomena by changing the relative situations of the bodies to each other, in all of which manifestations of an inverse character to those of ordinary magnetism are developed. If one of the spheres be mounted so as to be free to move about a vertical axis, it is found that, when a second oscillating sphere is brought near to it, the one that is free turns round its axis, and sets itself so that both spheres shall be simultaneously approaching or receding from each other. Two oscillating spheres mounted at the extremities of an arm, with freedom to move, behave with respect to another oscillating sphere exactly like a magnet in the neighborhood of another magnetic pole. These directive effects are believed by Professor George Forbes to be perfectly new, both theoretically and experimentally.

The phenomena of attraction and repulsion, described above, are

supposed by Professor Bjerknes and Professor Forbes to be due, not to the action of one body on the other, but to the mutual action of one body and the water in contact with it, the water being regarded as the analogue of Faraday's medium. "Viewed in this light," says Professor Forbes, "his first experiment is equivalent to saying that, if a vibrating or oscillating body have its motions in the same direction as the water, the body moves away from the center of disturbance; but, if in the opposite direction, toward it. This idea gives us the analogy of dia- and para-magnetism. If, in the neighborhood of the vibrating drum, we have a cork ball, retained under the water by a thread, the oscillations of the cork are greater than those of the water in contact with it, owing to its small mass, and are, consequently, relatively in the same direction. Accordingly, we have repulsion, corresponding to diamagnetism. If, on the other hand, we hang in the water a ball which is heavier than water, its oscillations are not so great as those of the water in its vicinity, owing to its mass, and consequently the oscillations of the ball relatively to the water are in the opposite direction to those of the water itself, and there is attraction corresponding to para-magnetism. A rod of cork and another of metal are suspended horizontally by threads in the trough, and a vibrating drum is brought near them: the cork rod sets itself equatorially, and the metal rod axially."

FIG. 2.



From these and other experiments Professor Bjerknes has concluded that the motion of a vibrating agent in the water produces a real magnetic field, with its lines of forces presenting, but always in an inverse sense, identical phenomena of diamagnetism and para-

magnetism, magnetic interference, etc. He has been able to trace out the direction of the lines of force produced in the liquid with the apparatus represented in Fig. 2. A light sphere or cylinder is mounted in the midst of the liquid upon an elastic rod, so that it shall partake of every movement of the surrounding water; a brush is attached to it, and arranged in such a manner as to paint, on the glass plate above, the line of every vibration of the fluid important enough to move it. If two drums are used pulsating concordantly, a figure is obtained precisely like that produced by iron filings in a field of two similar magnetic poles. If the pulsations are discordant, the figure is like that obtained with two dissimilar poles. Three pulsating drums give a figure identical with that produced by three magnetic poles.

A number of interesting conclusions may be drawn from these experiments concerning the nature of electric and magnetic vibrations, but they need to be further confirmed before a positive announcement of them can be justified.

THE CAUSE OF TUBERCULAR DISEASE.

LETTER FROM PROFESSOR TYNDALL TO THE LONDON "TIMES."

ON the 24th of March, 1882, an address of very serious public import was delivered by Dr. Koch before the Physiological Society of Berlin. It touches a question in which we are all at present interested—that of experimental physiology—and I may, therefore, be permitted to give some account of it in the "Times." The address, a copy of which has been courteously sent to me by its author, is entitled "The Etiology of Tubercular Disease." Koch first made himself known by the penetration, skill, and thoroughness of his researches on the contagium of splenic fever. By a process of inoculation and infection he traced this terrible parasite through all its stages of development and through its various modes of action. This masterly investigation caused the young physician to be transferred from a modest country practice, in the neighborhood of Breslau, to the post of Government Adviser in the Imperial Health Department of Berlin.

From this department has lately issued a most important series of investigations on the etiology of infective disorders. Koch's last inquiry deals with a disease which, in point of mortality, stands at the head of them all. If, he says, the seriousness of a malady be measured by the number of its victims, then the most dreaded pests which have hitherto ravaged the world—plague and cholera included—must stand far behind the one now under consideration. Koch makes the startling statement that one seventh of the deaths of the human race are due to tubercular disease, while fully one third of those who die in

active middle age are carried off by the same cause. Prior to Koch it had been placed beyond doubt that the disease was communicable; and the aim of the Berlin physician has been to determine the precise character of the contagium, which previous experiments on inoculation and inhalation had proved to be capable of indefinite transfer and reproduction. He subjected the diseased organs of a great number of men and animals to microscopic examination, and found, in all cases, the tubercles infested with a minute, rod-shaped parasite, which, by means of a special dye, he differentiated from the surrounding tissue. It was, he says, in the highest degree impressive to observe in the center of the tubercle-cell the minute organism which had created it. Transferring directly, by inoculation, the tuberculous matter from diseased animals to healthy ones, he in every instance reproduced the disease. To meet the objection that it was not the parasite itself, but some virus in which it was imbedded in the diseased organ, that was the real contagium, he cultivated his *bacilli* artificially, for long periods of time, and through many successive generations. With a speck of matter, for example, from a tuberculous human lung, he infected a substance prepared, after much trial by himself, with the view of affording nutriment to the parasite. Here he permitted it to grow and multiply. From this new generation he took a minute sample and infected therewith fresh nutritive matter, thus producing another brood. Generation after generation of *bacilli* were developed in this way without the intervention of disease. At the end of the process, which sometimes embraced successive cultivations extending over half a year, the purified *bacilli* were introduced into the circulation of healthy animals of various kinds. In every case inoculation was followed by the reproduction and spread of the parasite, and the generation of the original disease.

Permit me to give a further, though still brief and sketchy, account of Koch's experiments. Of six Guinea-pigs, all in good health, four were inoculated with *bacilli* derived originally from a human lung, which, in fifty-four days, had produced five successive generations. Two of the six animals were not infected. In every one of the infected cases, the Guinea-pig sickened and lost flesh. After thirty-two days one of them died, and after thirty-five days the remaining five were killed and examined. In the Guinea-pig that died, and in the three remaining infected ones, strongly pronounced tubercular disease had set in. Spleen, liver, and lungs were found filled with tubercles; while in the two uninfected animals no trace of the disease was observed. In a second experiment, six out of eight Guinea-pigs were inoculated with cultivated *bacilli*, derived originally from the tuberculous lung of a monkey, bred and rebred for ninety-five days, until eight generations had been produced. Every one of these animals was attacked, while the two uninfected Guinea-pigs remained perfectly healthy. Similar experiments were made with cats, rabbits, rats, mice, and other

animals, and, without exception, it was found that the injection of the parasite into the animal system was followed by decided and, in most cases, virulent tubercular disease.

In the cases thus far mentioned inoculation had been effected in the abdomen. The place of inoculation was afterward changed to the aqueous humor of the eye. Three rabbits received each a speck of *bacillus* culture, derived originally from a human lung affected with pneumonia. Eighty-nine days had been devoted to the culture of the organism. The infected rabbits rapidly lost flesh, and after twenty-five days were killed and examined. The lungs of every one of them were found charged with tubercles. Of three other rabbits, one received an injection of pure blood-serum in the aqueous humor of the eye, while the other two were infected in a similar way, with the same serum, containing *bacilli*, derived originally from a diseased lung, and subjected to ninety-one days' cultivation. After twenty-eight days the rabbits were killed. The one which had received an injection of pure serum was found perfectly healthy, while the lungs of the two others were found overspread with tubercles.

Other experiments are recorded in this admirable essay, from which the weightiest practical conclusions may be drawn. Koch determines the limits of temperature between which the tubercle-*bacillus* can develop and multiply. The minimum temperature he finds to be 86° Fahrenheit, and the maximum 104°. He concludes that, unlike the *bacillus anthracis* of splenic fever, which can flourish freely outside the animal body, in the temperate zone animal warmth is necessary for the propagation of the newly discovered organism. In a vast number of cases, Koch has examined the matter expectorated from the lungs of persons affected with phthisis and found in it swarms of *bacilli*, while in matter expectorated from the lungs of persons not thus afflicted he has never found the organism. The expectorated matter in the former cases was highly infective, nor did drying destroy its virulence. Guinea-pigs infected with expectorated matter which had been kept dry for two, four, and eight weeks respectively were smitten with tubercular disease quite as virulent as that produced by fresh expectoration. Koch points to the grave danger of inhaling air in which particles of the dried sputa of consumptive patients mingles with dust of other kinds.

It would be mere impertinence on my part to draw the obvious moral from these experiments. In no other conceivable way than that pursued by Koch could the true character of the most destructive malady by which humanity is now assailed be determined. And, however noisy the fanaticism of the moment may be, the common sense of Englishmen will not, in the long run, permit it to enact cruelty in the name of tenderness, or to debar us from the light and leading of such investigations as that which is here so imperfectly described.

SKETCH OF CHARLES R. DARWIN, LL.D.

MR. DARWIN died at his home, Down House, near Orpington, England, April 19th. He had been suffering for some time from weakness of the heart, but continued to work till the last. He was taken ill, after having enjoyed an apparent improvement, on the day before his death, with pains in the chest, faintness, and nausea, from which he never recovered.

Mr. Darwin inherited his scientific tastes from two successive generations of ancestors, and has transmitted them to some of his children. His grandfather, Dr. Erasmus Darwin, was a distinguished botanist, and was the author of a poem "The Botanic Garden," the merits of which are decidedly more botanical than poetical, but which has a place in English literature; and of the "Zoönomia, or the Laws of Organic Life," a work in which the theory of development was plainly foreshadowed. His father, Dr. Robert Waring Darwin, was a Fellow of the Royal Society. His grandfather on the mother's side was the celebrated Josiah Wedgwood, whose name is intimately associated with the Wedgwood earthenware.

CHARLES ROBERT DARWIN was born in Shrewsbury, England, February 12, 1809, and received a preparatory education at the grammar-school of that place, under the head-mastership of Dr. Samuel Butler, author of one of the old standard text-books on geography, and afterward Bishop of Litchfield and Coventry. He entered the University of Edinburgh when sixteen years old, and two years later, in 1827, went to Christ's College, Cambridge, whence he was graduated Bachelor of Arts four years afterward. The most that is known definitely of his special pursuits at these institutions is that at Edinburgh he gave some attention to marine zoölogy, and read his first scientific paper, "On the Movement of the Ova of Frustra" before the Plinian Society, and that at Cambridge he was especially interested in botany.

His Majesty's ships Adventure and Beagle had returned in 1830 from a four years' survey of the coasts of Patagonia and Terra del Fuego. Captain Fitzroy, of the Beagle, had gained so much credit by his efficiency as an officer and the value of the observations he recorded, that he easily obtained a commission to return to the South American waters on another and more extensive exploring expedition. Before going he made a public offer to give up a part of his own cabin to any competent naturalist who would accompany him. Darwin saw the notice, and at once offered his services without salary, on the condition that he should be given the disposition of his collections. He was accepted, and thus obtained, when twenty-two years old, "what would be considered a prize by any naturalist of double his age." The expedition, with Darwin as one of its members, sailed on the 27th of Novem-

ber, 1831, and was gone four years and ten months, during which time it visited Brazil, Patagonia, Chili, Peru, the Galapagos and Society Islands, New Zealand, Australia, Mauritius, St. Helena, and the Cape Verd Islands. The observations taken during this voyage and the previous expedition were published by Captains King and Fitzroy, their commanders, in a voluminous report, to which Mr. Darwin contributed a volume embodying "A Journal of Researches into the Geology and Natural History of the Various Countries visited by his Majesty's Ship Beagle, under the Command of Captain Fitzroy, from 1832 to 1836." Of this work Sir Charles Lyell wrote to the author, in September, 1838, before it was actually published: "I assure you my father is quite enthusiastic about your journal, which he is reading, and he agrees with me that it would have had a great sale if separately published. The other day he told me that he wished to get a copy bound the moment it was out, and send it as a present to Sir William Hooker, who, more than any one, would be delighted with yours. He was disappointed at hearing that it was to be fettered by the other volumes, for, although he should equally buy it, he feared so many of the public would be checked from doing so." The volume was published separately in 1845. The ten years which followed Mr. Darwin's return to England were mainly devoted by him to the publication of the numerous and important results that had been obtained during the voyage. He edited the treatises of Professor Owen, Mr. Waterhouse, Mr. Gould, the Rev. J. Jenyns, and Mr. Bell, on the different groups of vertebrate animals as "The Zoölogy of the Voyage of H. M. S. Beagle"; and he wrote three separate volumes embodying further fruits of his observations than he had given in the "Report," "On the Structure and Distribution of Coral Reefs" (1842); "Geologic Observations on Volcanic Islands" (1844); and "Geological Observations on South America" (1846). Of the first three works, a reviewer of the second edition in "Nature," in 1874, says: "The rising generation of naturalists and geologists have not had, and most probably will never have, such feelings of intellectual pleasure as fell to the lot of the readers of Charles Darwin's book on 'Coral Reefs,' which was offered to science more than thirty years ago. The recent researches into the nature of the deposits of the deep-sea, and the discoveries of bathymetrical zones of water of very different temperatures, are certainly full of vast interest, and will afford the data for the development of many a theory; but the clear exposition of facts, and the bold theory which characterized the book on 'Coral Reefs,' came unexpectedly and with overpowering force of conviction. The natural history of a zoophyte was brought into connection with the grandest phenomena of the globe—with the progressive subsidence of more or less submerged mountains, and with the distribution of volcanic foci." And this reviewer adds that "even at this period of Darwin's life the importance of the struggle for existence had been recognized by him, and had in-

fluenced his thoughts. He remarks that he 'can understand the gradation only as a prolonged struggle against unfavorable conditions.'" The President of the Geological Society has said that, "looking at the general mass of Mr. Darwin's results, I can not help considering his voyage around the world as one of the most important events for geology which has occurred for many years." Professor John W. Judd, noticing the works of this series in a group, said, in 1877, "Students of Mr. Darwin's earlier geological writings must all have been impressed by the powers of minute observation, the acumen in testing, and the skill in grouping data, and the boldness and originality in generalization which distinguished their author; for these characteristics are no less distinguished in the theory of coral reefs than in that of natural selection"; and "these 'Geological Observations' are well worthy to take their place in the long series of the author's contributions to the doctrine of descent side by side with those more widely known works on different departments of zoölogy and botany which have been published subsequently to the 'Origin of Species.'"

His most important work on zoölogy, "A Monograph of the Family Cirripedia," was published by the Ray Society, 1851 to 1853. It gave accurate determinations of every recognized species of the animals known as barnacles and sea-acorns; and was shortly afterward followed by another monograph on the fossil species of the same family, which was brought out by the Philosophical Society. All of these works—each of which was, as the estimates we have quoted indicate, of the first importance in itself, and each of which is a standard to this day—were but as preliminaries to the culminating achievement of Mr. Darwin's life, the exposition of the doctrine of the origin of species and development by natural selection, as given in the series of works on "The Origin of Species by Means of Natural Selection; or, the Preservation of Favored Races in the Struggle for Life" (1859); "The Variations of Plants and Animals under Domestication" (1867), and "The Descent of Man and Selection in Relation to Sex" (1871); and in the numerous special works in which he has made various particular phenomena of animal and vegetable life illustrate and re-enforce his great doctrine. The views expressed and defined in these works, although, now that they have "come of age," they have sensibly and profoundly affected the whole world of thought, were a surprise. Scientific men received them hesitatingly or with incredulity; those who were not scientific with displeasure. Yet they were not wholly novel; for Aristotle, Goethe, Mr. Darwin's grandfather, and others, had suggested similar hypotheses, and Mr. Wallace had independently reached conclusions very like those enunciated by Mr. Darwin. They have had to make their way against the prepossessions of the minds to whom they appealed, and against the prejudices which those prepossessions awakened when they were assailed.

Gradually the theory of descent gained acceptance among the

scientific thinkers of England, with whom the proportion of those ready to deny it grows less from year to year. In Germany it became, in the course of ten years, more or less completely accepted by those best qualified to judge, and was the occasion of the production of a considerable literature of arguments and facts in its favor, without encountering any very serious opposition. In France, the truth of the theory was far less extensively admitted, and it continued to be, for many years, the object of a vigorous and often bitter opposition, the echoes of which have hardly yet died away. A prolonged discussion took place in the French Academy of Sciences relative to the merits of the author of the theory in 1870, when Mr. Darwin was nominated to fill the vacancy in the zoölogical section caused by the death of M. Purkinge. M. Milne-Edwards first spoke in his favor, saying that, while he was himself absolutely opposed to evolutional doctrines, he rendered homage to the value of the special works of Mr. Darwin, especially to the theory of the formation of coral islands. M. Elie de Beaumont added his testimony to the value of this theory, and remarked that Mr. Darwin had done good work which he had spoiled by dangerous and unfounded speculations; he should not be elected until he had renounced them. M. Emile Blanchard was very severe upon Mr. Darwin for an hour, styling him an "intelligent amateur"; and M. Elie de Beaumont interpolated that his work was the "froth of science." M. de Quatrefages replied to M. Blanchard, saying that there were two men included in Mr. Darwin, a naturalist observer and a theoretical thinker: the naturalist is exact, sagacious, and patient; the thinker is original and penetrating, often just, sometimes too rash. That the theory with which his name is connected, that of natural selection, has in it something seductive and plausible, is shown by its having been worked out by such men as Darwin, Wallace, and Naudin, laboring independently and in different paths. If the ideas and the works of Darwin are such as some of his opponents represent, how can they have obtained the support, in less than ten years, of such men as Lyell, Hooker, Huxley, Karl Vogt, Lubbock, Haeckel, Filippi, and Brandt himself, who has just been elected correspondent in opposition to Mr. Darwin? Then, having enumerated Mr. Darwin's works in geology, comprising seven real contributions to the science, and in zoölogy, his works on the origin of species and variation, and particularly his investigations of the strange variations in fowls, pigeons, and rabbits, M. de Quatrefages summed up by saying: "Mr. Darwin is an eminent naturalist, who wishes to remove from science the invocation of the first cause, and to seek the explanation of the natural facts of the organic world in secondary causes, as was done long ago in geology, chemistry, and physics. But he goes no further; and we ought not to judge Darwin by the words of a few disciples who seem never to have read his works. It would be unjust to make him responsible for the exaggerations and

aberrations of those who take refuge under his name." M. Robin made an argument which presents a singular appearance now, in view of the hosts of minute but important facts which Mr. Darwin has showered upon science since it was made, that, in respect of demonstrable facts which he had introduced, there would be a hundred zoölogists who should have precedence over him. If from his publications "we eliminate the views, neither the reality nor falseness of which is demonstrable, and which are therefore not objects of science, there remains to him a share of titles which is inferior to that represented by the well-demonstrated scientific data introduced by M. Bischoff; there remain to him even fewer titles to our suffrages than to any of the *savants* who are placed on an equality with him in our list of presentations." Mr. Darwin was not elected. His name came before the Academy again, on a nomination to be a foreign correspondent, in 1872, and received the same support and the same opposition as two years before. He was rejected—receiving only fifteen votes, to thirty-two cast for Mr. Loewen, of Stockholm. His time came at last to receive the recognition of French men of science. He was elected a corresponding foreign member in the zoölogical section in 1878, by a vote of twenty-six to fourteen, after a rapid change in his favor, and three years after having received a similar recognition from the Imperial Academy of Science of Vienna. On the occasion of his sixty-ninth birthday, in 1877, he received, as a testimonial from Germany, an elegant album, containing the photographs of one hundred and fifty-four men of science in that country, addressed "To the Reformer of Natural History, Charles Darwin," and a similar album containing the photographs of two hundred and seventeen distinguished professors and lovers of science in the Netherlands, accompanied with an account of the progress of opinion in that country with respect to evolution, as a proof which, it expressed, "we are persuaded, can not but afford you some satisfaction that the seeds by you so liberally strewed have also fallen on fertile soil in the Netherlands." Mr. Darwin replied to the latter testimonial modestly, acknowledging his obligations to previous observers of facts, and adding: "I suppose that every worker at science occasionally feels depressed, and doubts whether what he has published has been worth the labor which it has cost him; but for the remaining years of my life, whenever I want cheering, I will look at the portraits of my distinguished co-workers in the field of science, and remember their generous sympathy." In 1877 the University of Cambridge, amid circumstances of great enthusiasm, conferred the degree of LL. D. on him in a Latin oration, in which his work was neatly summarized, and which closed, "Thou, also, who hast so learnedly illustrated the laws of nature, be our doctor of laws." A subscription was afterward inaugurated at Cambridge for the erection of a permanent memorial of him, which it was agreed should be a picture, to be painted by Mr. W. M. Richmond.

Mr. Darwin's later works, besides those which we have already named, which are for the most part monographs embodying facts and researches into the manner in which different functions of animals and plants are developed, include "The Various Contrivances by which Orchids are fertilized by Insects" (1862); "The Movements and Habits of Climbing Plants" (1865); "The Expression of the Emotions in Man and Animals" (1872); "Insectivorous Plants" (1875); "The Effects of Cross and Self Fertilization in the Vegetable Kingdom" (1876); "The Different Forms of Flowers and Plants of the Same Species" (1877); "The Power of Movement in Plants" (1881); "The Formation of Vegetable Mould through the Action of Worms, with Observations on their Habits" (1882). All of these works have been received with interest by the public, and have been fully noticed in our pages. The works which have been called forth by the influence of Mr. Darwin's writings are catalogued in a German pamphlet of thirty-six octavo pages, containing the names of three hundred and twelve authors.

Mr. Darwin was subject to frequent sudden attacks of illness which laid him prostrate for days together. The periods of convalescence were made useful for observations requiring almost constant attention; and such observations, made in the sick-room, are referred to in his "Climbing Plants." His tastes were almost wholly scientific. For sculpture or pottery, or even for drawing, except as an aid to botanical and zoölogical pursuits, he cared very little, his collection of pictures being confined to a portrait of old Dr. Darwin and one of Josiah Wedgwood, hanging in his dining-room, and sketches of Sir Joseph Hooker and Professor Huxley in his study.

Commenting on Mr. Darwin's methods of investigation and presentation, "Nature" remarks in a review of one of his books, that, in turning over its pages, "one is almost distracted from the intrinsic interest of the facts and speculations by the sagacity with which the research is carried on, and the skill with which the results are marshaled for our information. It is peculiarly worthy of notice . . . how the reader is allowed, in studying Mr. Darwin's pages, to form his own hypothesis in explanation of the facts, only to be compelled, in due course, as the narrative proceeds, to admit that such hypotheses are utterly untenable." Scientific candor is mentioned as one of his prominent qualities by Mr. J. W. Judd, who says that, "like his teacher and friend, the late Sir Charles Lyell, he never forgets in his discussions to look at all sides of the questions before him, and to give the fullest expression and weight, alike to the difficulties which he himself detects, and to arguments which opponents may have advanced." This quality is well illustrated in the successive editions of the "Origin of Species," where the author's changes or modifications of views in particular points are frequently acknowledged and recorded.

EDITOR'S TABLE.

CHARLES ROBERT DARWIN.

THE present year will be memorable in the history of science as bringing to a close the labors of two illustrious scientific thinkers—one, perhaps, the most eminent man of science in America, Dr. John William Draper, and the other probably the most celebrated scientific man of the world at the present time, Dr. Charles Robert Darwin. Both men had accomplished their work, the former dying at the age of seventy-one, and the latter at the age of seventy-three; and it is remarkable that both were among the most distinguished representatives of the same school of progressive scientific thought. Their names will be for ever associated with that great revolution of ideas for which all modern science has prepared, but which has been accomplished only within the present generation. Both men made large and important contributions, by observation and experiment, to the departments of science which they respectively cultivated, but they will be measured in future chiefly by the bearing of their work upon the great intellectual movement of the period.

Everybody knows what we mean in speaking of the movement of thought with which the names of Draper and Darwin are identified; and which we have referred to as a revolution of ideas already accomplished. One of its leading aspects is the application of the scientific method to the phenomena of life in order to explain their changes by natural causes. Mr. Darwin's name has been so closely associated with this extension of scientific method to cover the origin of the diversities of living beings upon earth that he has come to be a representative of the idea; while the term "Darwinism" has been vaguely employed to stand for the doctrine. The twenty volumes of "The Popular Science Monthly" bear uniform and abundant record that "Darwinism" has been generally accepted as true in the world of science for the last ten years. But there is a sharper test of the change of opinion that has taken place than any affirmation regarding the verdicts of scientific men. At its earliest promulgation "Darwinism" was denounced by the whole body of religious authorities as false and execrable. There was never such unanimity in the pulpit as was displayed in cursing the new apostle of the doctrine of man's descent from an ancestry of inferior animals. The devil got a considerable respite while the batteries were all being turned upon Darwin as the arch-enemy and subverter of all religion. But, as the movement of ideas went on all the same, common sense began to assert itself in various quarters, so that there has latterly been more temperateness of condemnation, and even a readiness to accept the long-detested doctrine as probably true, and by no means so bad as it at first seemed. And, now that Darwin is dead, there is a universal burst of admiration for the man, accompanied by abundant admissions that his ideas are true; and he is laid in Westminster Abbey alongside of Newton, while the most eminent preachers of London agree in declaring that there has been nothing in his teaching that is not wholly consistent with the soundest Christian belief. Canon Liddon, of St. Paul's, author of "The Divinity of our Lord and Saviour Jesus Christ," is reported to have said in a sermon that "Mr. Darwin's theories are not necessarily hostile to the fundamental truths of religion"; and Canon Barry, author of "Orthodox Commentaries on Portions of the Bi-

ble," declared that "the doctrine of evolution lent itself as readily to promises of God as less complete explanations of the universe."

To explain the world-wide fame of Mr. Darwin and the expressions of high appreciation that have been elicited by his death, several circumstances must be taken into account. In the first place, his pre-eminence as a naturalist is not for a moment to be questioned. He had a genius for investigation in this field, as is shown by the immense amount of valuable and original work that he has accomplished. As an accurate and indefatigable observer, of keen insight, and equally fertile and skillful in his experimental devices to bring out the secrets of Nature, he was probably without a rival. Descended from a race of naturalists, he seemed to have a constitutional intuition for penetrating the mysteries of living beings, and detecting subtilties that had eluded previous observers. Patient, industrious, and concentrated upon his work, he has enriched natural history with a multitude of new facts, which will make his name an authority for all future time.

But Mr. Darwin was more than a mere observer and accumulator of facts; he was a man of ideas capable of methodizing his observations and making them tributary to the progress of theoretical views. He found the problem of the origin of the diversities of living beings unsettled, he subordinated all his researches to its solution, and he put forth a theory upon the subject that has made him famous. This was the principle of natural selection, called also the survival of the fittest, and it was elaborated with a wealth of illustration that rapidly commended it to the acceptance of the scientific world. In a nutshell it is this: There is a law of heredity, or descent of traits, from generation to generation, in the kingdom of organic life—a law under which "like produces like." But there is also a law of variation by which like always produces the slightly unlike—a modification from generation to generation, and adaptation to ever-changing conditions. At the same time the rate of multiplication gives rise to a destructive struggle for existence, in which multitudes perish and but comparatively few survive, while the survivors are those best fitted to the new conditions. In this way new characters are strengthened and developed, and old traits are weakened and disappear, so that the progress of life is at the same time a slow transformation, in which at first new varieties and then new species gradually arise by minute increments of change. Thus the diversities among living creatures are accounted for by the operation of natural agencies.

But, besides the intrinsic character of his work, the traits of the man were eminently calculated to produce the most favorable impression. He was not a controversialist, and, instead of going roughly athwart men's prejudices, he was kindly, considerate, and conciliatory in all his writings. He was also modest and eminently candid and fair-minded, always seeking to do justice to the views of his opponents. Men felt that his supreme object was simply to get at the truth. For this he labored incessantly and untiringly, and thus won the respect of all who can appreciate sincerity of aim and elevation of purpose. Added to this he was a very genial and pleasant man in his personal relations, and most highly regarded by those who were honored with his acquaintance and friendship.

But still other elements must be taken into account in explaining the extent of his popularity. He was a remarkably fortunate man. We refer not so much to his easy circumstances, which gave him command of resources and allowed full consecration to a life of study; but we mean that he came at a great crisis of thought, when a lead-

er was wanted in a comprehensive scientific field. It was his happy fortune to avail himself of a previous advance of biological inquiry, which was much greater than is generally supposed. Mr. Darwin has himself fully pointed out to what various extents his idea of natural selection had been discerned by preceding naturalists. It was a discovery all ready to be made, and how inevitably it grew out of the state of knowledge that had been attained, and how imminent it was in the thought of the time, is shown by the fact that he was compelled to publish on the subject earlier than he had intended, to prevent being anticipated by Mr. Alfred Russel Wallace, who had already arrived at and worked out the same principle. It was fortunate for the fame of Mr. Darwin that Mr. Wallace so gracefully and generously stepped aside, and surrendered to him the full leadership of the new biological reform.

Nor is it to be forgotten, in enumerating the causes that have conspired to give such prominence to the name and fame of Darwin, that his subject was one of intense and universal interest. No matter how unpalatable were the theories proposed, everybody was concerned with questions of the origin of life, because they involved explanations of human origin. Whence we came has always been a riddle which there has been an irrepressible curiosity to solve. Mr. Darwin's explanation came in the name of science, and, apparently involving but a single principle of such simplicity and familiar illustration that everybody could understand it, his little book was sought for and read with avidity by all classes. And yet, in the nature of things, it was impossible that the work should be generally understood with any thoroughness. It dealt with an order of ideas for which our higher education made no preparation, so that the college graduate was little better equipped than the uneducated country farmer to read intelligently and appreciatingly the argument of the "Origin of Species." There was, consequently, a great deal of popular confusion and misapprehension as to what Mr. Darwin had really done, and which naturally led to erroneous and even extravagant claims as to the nature and scope of his work. To those who were not well instructed he came to be regarded as the creator of an epoch and the originator of the whole scheme of ideas connected with his investigations. We see this in the tendency to attribute to Mr. Darwin the fatherhood of the law of evolution, and to identify evolution with Darwinism. He contributed to that universal law a most important principle, but he was neither its founder nor did he ever attempt anything like its general exposition. That great doctrine had been overwhelmingly proved, had been resolved into its forces, formulated, and extensively applied to the reorganization of scientific knowledge, before Mr. Darwin had ever published a word upon the subject. He has done noble work, and his position is for ever assured among the greatest in science; and, if circumstances have tended to favor some exaggeration of his real claims, we may leave to time the correction of imperfect judgments, and the equitable award of all honors among those to whom honors are due.

A VERY MODERN REPROACH.

COMMENTING, two months ago, upon Goldwin Smith's article attacking scientific ethics, we pointed out the extensive co-existence of supernatural beliefs with a lax morality. The "Christian Union," under the title of "A Very Ancient Reproach," charges "The Popular Science Review" with reviving a stale old accusation of Thomas Paine. It, moreover, attempts to confound us with "History," and offers a quotation from Gibbon, declaring that through conversions by the early Church "the

most abandoned sinners" in many cases became "the most eminent saints." The "Union" then proceeds to remark: "If 'The Popular Science Monthly' desires further information as to the actual effect which evangelical religion has produced on the morals of the community, it will be found in abundance in Lecky's 'History of European Morals,' in the same author's 'History of England in the Eighteenth Century,' and in Professor Draper's 'History of the Intellectual Development of Europe,' and none of these authors can be accused of being eulogists of Christianity. We leave the 'Review' to settle it with Gibbon which horn of the dilemma it will accept."

We have no issue with Lecky or Draper, and nothing to settle with Gibbon. If we had no other source of information respecting the relations of faith and morals as manifested in human conduct, than what was written a hundred years ago about what took place sixteen hundred years earlier, it would be different; but the illustrations of the relation of religious belief to ethical practice are too clear, familiar, and impressive all around us to make this course necessary. On living questions we prefer living authorities, and judgments based upon immediate observation and experience, to historic inferences regarding what took place at remote periods. Accordingly, we value the testimony of the editor of the "Christian Union" higher than even that of Gibbon, while his record is far more to the point. The article entitled "A Very Ancient Reproach" is immediately followed by another which serves as an instructive comment upon it by showing that the "reproach" is also both very modern and very real. Its title is "A Missouri Saint," and the editor writes upon the subject with an openness which "The Popular Science Monthly" has never emulated. He says:

St. James—St. Jesse James—is the latest contribution of America to the noble army of saints and martyrs.—

Death seems to settle all accounts; and no sooner was this murderous villain dead, than the whole community set to work with extraordinary unanimity to canonize him. His funeral was an ovation; the attendant throng crowded the Baptist church, "where he was converted in 1866"—heavens! what sort of a man would he have been if he had not been converted?—the sheriff and under-sheriff acted among the pall-bearers; the services were opened with the hymn "What a friend we have in Jesus!" the officiating ministers comforted the stricken community with extracts from the plaints of Job and David, and with a comforting discourse on Christ's forbearance and forgiveness of sins; and, finally, the procession to the grave was one of immense proportions.

Out upon such a religion as this! If a Dr. Thomas intimates that there may be perhaps a probation in another world for those who seem to have had no true probation in this, he is turned out of the fellowship of the church as a heretic. If a Mr. Jones and a Mr. Martin send a freebooter and a life-long robber and murderer straight to heaven in a chariot of fire without as much as a baptismal bath by the way, will any church call them to account for their falseness to the law of God and the sacredness of morality? We shall see.

Excellent, certainly! But, if exactly the same sentiments, only pitched in a lower key of indignation, appear in "The Popular Science Monthly," we are accused of reviving the obsolete reproaches of infidelity, and the "Christian Advocate" breaks into a pious diatribe about "Sugar-coated Poison."

The view of the "Christian Union" is well confirmed by "The Nation," as follows:

James's relations to the Church, too, had a curiously mediæval flavor about them. He was the son of a Baptist minister, but his career apparently did not strike his mother, or any of his family or neighbors, as inconsistent with the possession of a stock of fundamental and ineradicable piety. When he died, she rejoiced in the thought that he had gone to heaven. Two Baptist ministers performed the funeral services, and a vast concourse of friends, including the sheriff, who was deeply affected, followed the remains to the grave, not sorrowing, apparently, as those

who are without hope. In fact, the James territory, which includes the adjacent corners of four States, is a region which seems closely to resemble in its religious and moral condition a Frankish kingdom in Gaul in the sixth century. Every one knows how very early in the history of the Church the tendency to make faith take the place of right-living began to show itself. St. James had to warn the very first generation of Christians that pure religion and undefiled consisted not in sound belief, but in good deeds. The difficulty of making people show their faith by their works has beset Christianity ever since. Barbarians rapidly accepted the Christian dogmas, and took eagerly to the rites and ceremonies of the Church, but they never were quite ready to accept its views about behavior. Gregory of Tours, in his most instructive chronicle, tells some very grotesque stories of the difficulties which the bishops had in Gaul in his day in refusing the communion to notorious evil livers. One Frankish chief—a great robber and cut-throat—insisted on having it administered to him, and the bishop had to let him have it, in order to save life, for he threatened to kill all the other communicants if he was not allowed to partake also. The comfort the Italian and Greek brigands find in the external observances of their creed, while committing the most atrocious crimes, is now an old story. A skeptical or agnostic robber is in fact unknown in Eastern or Southern Europe.

The devout brigands all belong to the Catholic or Greek Church, which has always greatly exalted the value of external worship and pious credulity, and thus furnishes only too much temptation to those who are ready to believe without limitation for the purpose of postponing any change in their habits. The Protestant Church has been much more exacting in the matter of conduct, and in fact has afforded in its teaching but few of the refuges for easy-going sinners which its great rival provides so plentifully. But the fight between faith and right-living nevertheless rages within its borders unceasingly, and not always to the advantage of the latter. It is not only in the James district in Missouri that one comes on the strange compromises by which a certain external devoutness is made to atone to the conscience not only for spiritual coldness, but for long and persistent violations of the fundamental rules of morality. Startling as are these revelations about the state of society in that part of the country, they are hardly more startling, everything considered, than the frequency with which our defaulters and embezzlers in this part of the world prove to have been vestrymen, deacons, Sunday-school superintendents, and prominent church-members during long years of delinquency and perfidy.

LITERARY NOTICES.

INTERNATIONAL SCIENTIFIC SERIES. No. XL.

MYTH AND SCIENCE. An Essay by TITO VIGNOLI. D. Appleton & Co. Pp. 372. Price, $1.50.

THOUGH an opportune and much-needed book upon a subject that is exciting wide attention in the higher circles of inquiry, yet this treatise is of a much graver character than its title might imply to those familiar with current mythic literature. It is not a book of old fairy tales nor of the mythological legends of different peoples, but it is a compact disquisition on the origin and nature of the common mythical element manifested by all grades of intelligence. It is a philosophical essay, and some critics declare it to be as hard as metaphysics, which is saying a good deal, because the book is far more interesting than metaphysics.

A leading element of interest in this volume comes from the point of view taken by the author in the investigation. He assumes evolution without any reserve, and declares that "it is evident, at least to those who do not cling absolutely to old traditions, that man is evolved from the animal kingdom." It is true that Mr. Max Müller, the grammarian of mythical romance, not long ago republished his prophecy that "the idea of a humanity emerging slowly from the depths of animal brutality can never be maintained again in our century." But it certainly does not look much as if the doctrine were at present thus discredited. Mr. Darwin, its great apostle, was yesterday entombed in Westminster Abbey with the singing of an anthem composed expressly for the occasion, in the presence of the best talent of the country and a formal deputation from the University of Oxford and representatives from learned societies, the import of the whole being that "Darwin's work was at length claimed by the nation as its own," while, by the verdict of Europe, the author of the "Descent of Man" was pronounced to be the greatest scientist of his age. At

any rate, Mr. Vignoli has the science of the world and probably the truth of the case on his side. But, if man was developed from the lower animals, he has derived his psychical faculties, as well as his bodily organism, from his inferior ancestors; and, although he has left them by a wide gap, they are still parts of a series with so much remaining in common that the higher can only be interpreted in derivative connection with the lower. On this view the mythical element, as considered by our author, begins with the lower animals, and comparative psychology is appealed to, with many special experiments, to show that animals endow the objects around them with a consciousness like their own. Man, in his early stages, does a similar thing by "animating" the forces and objects of nature, and filling the world with mythical personalities. This process goes on, according to Mr. Vignoli, with the advance of intelligence, so that science, instead of ending myths, only modifies them. Man "personifies all phenomena, first vaguely projecting himself into them, and then exercising a distinct purpose of anthropomorphism until, in this way, he has gradually modified the world according to his own image."

In his opening chapter on the ideas and sources of myths, Mr. Vignoli thus presents the point of view from which he considers the subject:

> We do not propose to consider in this treatise the myths peculiar to one people nor to one race; we do not seek to estimate the intrinsic value of myths at the time when they were already developed among various peoples and constituted into an Olympus or special religion; we do not wish to determine the special and historical cause of their manifestations in the life of any one people, since we now refrain from entering on the field of comparative mythology. It is the scope and object of our modest researches to trace the strictly primitive origin of the human myths as a whole; to reach the ultimate fact, and the causes of this fact, whence myth in its necessary and universal form is evolved and has its origin.
>
> We must, therefore, seek to discover whether, in addition to the various causes assigned for myth in earlier ages, and still more in modern times, by our great philologists, ethnologists, and philosophers of every school—causes which are for the most part extrinsic—there be not a reason more deeply seated in our nature, which is first manifested as a necessary and spontaneous function of the intelligence, and which is, therefore, intrinsic and inevitable.
>
> In this case myth will appear to us, not as an accident in the life of primitive peoples varying in intensity and extent, not as a vague conception of things due to the erroneous interpretation of words and phrases, nor again as the fanciful creation of ignorant minds; but it will appear to be a special faculty of the human mind, inspired by emotions which accompany and animate its products. Since this innate faculty of myth is indigenous and common to all men, it will not only be the portion of all peoples, but of each individual in every age, in every race, whatever may be their respective condition.
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> Myth, therefore, will not be resolved by us into a manifestation of an obsolete age, or of peoples still in a barbarous and savage state, nor as part of the cycle through which nations and individuals have respectively passed or have nearly passed; but it remains to this day; in spite of the prevailing civilization which has greatly increased and is still increasing, it still persists as a mode of physical and intellectual force in the organic elements which constitute it.

EASY LESSONS IN SCIENCE. Edited by Professor W. F. BARRETT. LIGHT. By Mrs. W. AWDRY. Pp 114. HEAT. By C. W. MARTINEAU. Pp. 136. Macmillan & Co.

VERILY, verily, if the children of this generation do not grow wise in science, it will not be for lack of elementary books for the purpose. "Rudimentary Lessons," "Elementary Lessons," "Simple Lessons," "Easy Lessons," and "Primers" innumerable, separate and in groups, edited by one book-maker and written by others, are already multiplied on every hand, and are increasing more rapidly than ever. They must be purchased, or they would not continue to be made; and, if purchased, they are probably read and used—so that, on the whole, we may assume that the result is good. But one thing is certain—the excellence of these books is in no relation to their numbers, nor is it easy to discern much if any improvement in the successive series. They are all lesson-books with abundant pictures to be learned in the old-fashioned way in the school-room. There is some effort at cheapening the means of experiment for scientific illustration, and, in so far as this promotes demonstration, the effect is undoubtedly beneficial. But these little manuals generally display but a very limited acquaintance with the minds of the young, and they are all conformed to the common type of books of information to be obtained by the regular old process of reading and lesson-learning.

The two volumes before us on "Light" and "Heat" are of the usual character. The name of Professor Barrett as editor may be taken as a guarantee that the volumes are accurate in their statements, but we see no evidence that the editorship goes any further. They seem to be ordinary text-books merely reduced in dimensions. Good teachers might use them, we think, with good effect, but good teachers are few, and the best teachers are independent of their books. On the other hand, bad teachers are innumerable—they are the rule, and the real question about primary books is how they work in the hands of incompetent teachers. The best books in these circumstances are those that favor the self-education of the pupil, and release him from the over-meddling of stupid instructors. The books before us, it is needless to say, are not of that order.

DIE CHEMISCHE URSACHE DES LEBENS THEORETISCH UND EXPERIMENTELL NACHGEWIESEN. (The Chemical Cause of Life theoretically and experimentally demonstrated.) By OSCAR LOEW and THOMAS BOKORNY, of Munich. Munich, Bavaria. 1881. Pp. 60, with a Colored Plate.

SINCE the first synthesis of an organic body, urea, was made by Wöhler in 1828, say the authors of this treatise, vital force has been regarded as the result of chemical and physical processes. This has been accepted as satisfactory till the present time, notwithstanding it has been necessary to admit, on a closer consideration, that a clearer definition of the chemical activity by which living protoplasm is governed would be hailed as a very desirable step of progress. The idea that there was a chemical difference between dead and living protoplasm never found expression till 1875, and nearly all physiologists still hold the view that a complete chemical identity exists between them, notwithstanding that it would be hardly possible to explain the cause of life if this were the case. E. Pflüger was the first to assert, in 1875, in a paper on physiological combustion in living organisms, that a chemical difference must necessarily exist between living and dead protoplasm. One of the authors of this treatise, in verifying an hypothesis he has proposed on the formation of albumen, met with a number of unaltered Aldehyde groups which stood in close relations with the Amidon groups, and immediately conceived the idea that the source of the vital movement in protoplasm was to be sought in the Aldehyde groups with their intense atomic movements, and the origin of death in the passage of the Aldehyde groups into Amidon groups. Shortly afterward both the authors succeeded in demonstrating the real existence of Aldehyde groups in living plasma. The present monograph gives a full and connected account of their experiments, and of the verifications of them.

THE OYSTER INDUSTRY. By ERNEST INGERSOLL. Washington: Government Printing-Office. Pp. 251, with Forty-two Plates.

THE present monograph is a part of a series on "The History and Present Condition of the Fishery Industries," which is in course of publication under the direction of the United States Fish Commission, in connection with the census. The arrangement of the main part of the work is geographical, beginning with the maritime provinces of Canada, and passing, with copious accounts of the culture and trade in oysters at all important points on the Atlantic coast, to the Gulf of Mexico and the Pacific coast. Chapters follow on the utilization of oyster-shells, and the natural history of the oyster, with notices of the fatalities to which it is subjected. "An Oysterman's Dictionary" offers an entertaining as well as informing collection of phrases and words descriptive of mollusks and other invertebrates of the Atlantic coast. Statistical tables are given in the final chapter.

A MONOGRAPH OF THE SEAL-ISLANDS OF ALASKA. By HENRY W. ELLIOTT. Washington: Government Printing-Office. Pp. 176, with Two Maps.

THE fur-seal was very often mentioned in the discussions that took place during the negotiations for the acquisition of Alaska, but very little was known of it, and it was hardly represented in the best zoölogical collections. The author of this monograph became interested in the subject, and in 1872, by the joint action of the Secretary of the Treasury and Professor Baird, was

enabled to visit the Pribylov Islands and study the life and habits of the animals. The notes, surveys, and hypotheses here presented are founded on his personal observations in the seal-rookeries of St. Paul and St. George, during the seasons of 1872, 1873, 1874, and 1876. They "were obtained through long days and nights of consecutive observation, from the beginning to the close of each seal season," and cover, by actual surveys, the entire ground occupied by these animals.

THE AREAS OF THE UNITED STATES, THE SEVERAL STATES AND TERRITORIES, AND THEIR COUNTIES. By HENRY GANNETT, E. M., Geographer and Special Agent of the Tenth Census. Washington: Government Printing-Office. Pp. 20, with Map.

THE question, "What constitutes the area of the United States?" is by no means a simple one, but involves other questions of including or leaving out inlets, and the measurement of numerous gores. For the purpose of this work the main area was procured by summing up the square degrees, and the areas of the fractions of square degrees were computed after direct measurement, with scales on the maps of the Coast, Lake, and Mexican Boundary Commission surveys. The whole contour of the country is thus given by surveys whose accuracy is unquestioned, except as to the part between the Lake of the Woods and Lake Superior, and a part of the eastern boundary of Maine, of which exact surveys have not been made. The same principles were observed in computing the areas of States and counties, where, however, boundary surveys are often not so accurate as they should be.

STATISTICS OF THE PRODUCTION OF THE PRECIOUS METALS IN THE UNITED STATES. By CLARENCE KING, Special Agent of the Census. Washington: Government Printing-Office. Pp. 94, with Six Plates.

THIS statistical statement is offered in advance of the author's report on the production of the precious metals, of which it will form the concluding chapter, on account of its immediate interest to legislators, financiers, and metallists. It consists almost wholly of statistics, presented in a full and clear manner.

ANNUAL REPORT OF THE CHIEF SIGNAL-OFFICER OF THE ARMY TO THE SECRETARY OF WAR, FOR THE YEAR 1881. Washington City. Pp. 86.

THE Signal Service continues to manifest its value, particularly in the meteorological department. The present officer, General Hazen, has endeavored to bring it into active sympathy and co-operation with men of science; and it enjoys the assistance of an advisory committee of the National Academy of Sciences. The work of the year has been marked by advance in nearly every department, among the evidences of which we notice the establishment of a permanent school of instruction at Fort Myer, Virginia; the extension of forecasts to periods of more than twenty-four hours; the forecasts of "northers" for the interior plateau; the extension of the special frost-warning to the fruit interests; the organization of a service for the special benefit of the cotton interest; arrangements for original investigation in atmospheric electricity, in anemometry and in actinometry; and in the last subject, especially with reference to the importance of solar radiation in agriculture, and the absorption of the sun's heat by the atmosphere; the publication of special professional papers; the offering of prizes for essays on meteorological subjects; the organization of State weather services; co-operation in work in the Arctic regions; arrangements for organizing a Pacific coast weather service; and a large increase of telegraphic weather service, without additional expense to the United States. The popular confidence and support of the bureau, General Hazen says, have never been impaired, and the scope of its usefulness increases with each year.

THE CONSTANTS OF NATURE, PART V.: A RECALCULATION OF THE ATOMIC WEIGHTS. By FRANK WIGGLESWORTH CLARKE, S. B., Professor of Chemistry and Physics in the University of Cincinnati. Washington: Smithsonian Institution. Pp. 279.

THIS work and Professor George F. Becker's "Digest" of the investigations of "Atomic Weight Determinations, published since 1814," which forms Part IV of the series of "Constants," are complementary to each other. Professor Clarke began his investigations in 1877, for the purpose of

revising the determinations of the atomic weights of all the elements. He does not claim that any of the results he has reached are final, but admits that each one of them is liable to repeated corrections. The real value of the work, he believes, lies in another direction; the data have been brought together and reduced to a common standard, and the probable error has been determined for each series of figures. Thus the ground is cleared, in a measure, for future experimenters.

THE CHEMISTRY OF COOKING AND CLEANING: A MANUAL FOR HOUSEKEEPERS. By ELLEN H. RICHARDS, Instructor in Chemistry, Woman's Laboratory, Massachusetts Institute of Technology. Boston: Estes & Lauriat. Pp. 90. Price, $1.

WE are glad to see such a book by such an author from such a place. A lady engaged in teaching practical chemistry in an institute of technology, and applying her science to the art of improving domestic life, affords an example of the fitness of things which is seen much too rarely. To the eye of a stupid public opinion, cooking and cleaning are very vulgar things—the operations of menials and scullions. But to the eye of science they are most interesting processes, tasking thought to master them, giving pleasure in understanding them, and valuable benefit in applying them. To the eye of ignorance, however cultivated, there is nothing about cooking and cleaning that is worthy of respect, and they are therefore left to the incompetent, who give us bad work; but, if they were better understood, practice would be improved, and we should have more wholesome cookery and more perfect cleanliness.

Mrs. Richards's neat little *brochure* is a contribution to domestic education which, though too slight, will be well appreciated. It is not an attempt to compress a great deal of information in a small compass, but to make the subject clear as far as it is treated. Her "Chemistry of Cooking" is at the same time a course of brief lessons in chemistry; that is, enough of the science is thoroughly explained to make its applications intelligible. We cordially commend it as an excellent beginning in a direction that must in future be more carefully and thoroughly pursued.

THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA. Ninth Annual Report, for the Year 1880. By N. H. WINCHELL, State Geologist. St. Peter, Minnesota. Pp. 392, with Six Plates.

THE work of the year covered by this report consisted chiefly of the arrangement for the museum of the crystalline rocks gathered during the previous seasons in the northern part of the State, including the cupriferous series; determinations in paleontology; examinations of building-stones; the study of the hydrology and water-powers; field work in the southwestern part of the State; and the examination of the "Lake region" of the center, with reference to hydrology and the distribution of forest-trees.

LA LUMIÈRE ÉLECTRIQUE; SON HISTOIRE, SA PRODUCTION, ET SON EMPLOI. (The Electric Light; its History, Production, and Employment.) By EM. ALGLAVE and J. BOULARD. Paris.

THE authors have taken advantage of the revelations which the recent International Electrical Exposition at Paris afforded of the extent to which electrical force has been developed as a working power, and the variety of purposes to which it has been practically applied, to prepare this elegant work, showing what has been done in that direction, when, and how. The large mass of material which they had to dispose of has been divided among six books, in the first of which is reviewed the history of artificial illumination, and the different phases through which it has passed from the dimly tempered darkness of the ancients, with their rude oil-lamps, through the stages of tallow, sperm, and stearine candles, and the improved lamps of modern days, to the beginnings of the electric light. The second book treats of voltaic or arc lights, the manner in which the arc is produced, the fabrication of the carbons, and the mechanism of the regulating apparatus, and furnishes descriptions of the different lights of this class. The third book is devoted to incandescent lamps, and includes descriptions of the Edison, Swann, Lane Fox, and Maxim lamps. In the fourth book the different kinds of apparatus for generating the electric current, and in the fifth book the several systems for securing its distribution and division, are described;

and the sixth book comprises accounts of the applications that have been made of the electric light in light-houses, war, navigation, in industry, the arts, and commerce, its installation in mines and excavations, railroad-stations, warehouses, and even in agricultural operations. All of these accounts are profusely illustrated with clear representations of the machinery and apparatus described, with a few landscapes electrically lighted. The authors have also given much information concerning the cost of establishing and maintaining the electric light for these several purposes. The work is thus not only one to be read, but also one that may be profitably consulted for practical purposes.

BI-MONETISM: THE MONEY OF COMMERCE AND THE MONEY OF THE STATE. By JOSEPH STRINGHAM. Oshkosh, Wisconsin. Pp. 64.

THIS pamphlet embodies the results of an inquiry which the author has made into the relations of the two moneys to each other, and into the utility of gold, silver, and paper as materials for money. He concludes that gold is the sole money of commerce, and will continue to be so as long as present commercial customs continue, but that the demand within the several States for paper or silver tokens for use in internal business is sufficient to absorb all the silver, and raise it to its coin value in gold, and keep it there. Silver, if its use for such a purpose should become general in the states of Europe and America, might thus eventually gain a recognized place as money in commerce, but not otherwise; while, under existing circumstances, "silver or any other metal could not be coined at its commercial value in gold without subjecting the coinage to frequent changes."

GUIDES FOR SCIENCE TEACHING. THE OYSTER, CLAM, AND OTHER COMMON MOLLUSKS. By ALPHEUS HYATT. With Plates. Pp. 65. COMMON MINERALS AND ROCKS. By WILLIAM O. CROSBY. Pp. 130. Boston: Ginn, Heath & Co.

WE noticed several months ago some volumes of a series of small hand-books published under the supervision of the Boston Society of Natural History, which were designed as aids to teachers wishing to instruct their pupils in branches of that department, but not to be used as text-books. We notice in addition to the works we then named the two whose titles stand at the head of this article. The manual on mollusks is fully illustrated with excellent plates, and Mr. Hyatt is strong in insisting that teachers can not use any text-book as a basis of good instruction, but must lead children to see for themselves. The system of classification set forth in Mr. Crosby's book on minerals is practically illustrated and exemplified in the arrangement of collections in the museum of the society.

THE NEW ETHICS: AN ESSAY ON THE MORAL LAW OF USE. By FRANK SEWALL. New York: G. P. Putnam's Sons. Pp. 61.

MR. SEWALL regards ethics as appertaining to the will rather than to the intellect; and suggests that it may be considered as a kind of moral æsthetics, or "æsthetics on the moral plane," and defined as a science of taste that treats of the will of man as subject to sensations of pleasure and of pain from moral objects presented to it, and capable of being affected and modified by them. The object of moral education is to adapt man to the moral law of the universe, which, assuming that it is real, may be expressed as the law of use, or of service, "but the law of mutual service, not the service of self." The author has no confidence in intellectual culture as an element of moral progress.

PROCEEDINGS OF THE BOSTON SOCIETY OF NATURAL HISTORY. Vol. XX, Part IV, January, 1880–April, 1880. Pp. 169; Vol. XXI, Part I, May, 1880–December, 1880. Pp. 112. Boston: Published by the Society.

THE papers of most general interest in the former of these two volumes are the notice of the death of Dr. Thomas M. Brewer, by President Bouvé; and the review of Professor Brewer's scientific labors, by Mr. J. A. Allen. The other volume contains notices of Mr. Bouvé's withdrawal from the presidency of the society, and of the deaths of Dr. C. T. Jackson, Count Pourtalès, Mr. L. S. Burbank, and Mr. George D. Smith. Many of the special papers, which concern

a wide variety of subjects in natural history, geology, physics, and archæology, have been noticed from time to time in "The Popular Science Monthly." Mr. S. H. Scudder, the new president of the society, defines its aim in his inaugural address as distinctively educational; and with this view it restricts its museum to the collection and exhibition of such objects as can be put directly to public use; furnishes direct instruction by lectures, lesson and guide books, to those who have in charge the education of youth; and is working for the introduction and retention of the study of nature in the public schools.

HOW TO MAKE THE BEST OF LIFE. By J. MORTIMER GRANVILLE, M. D. Pp. 96. Boston: S. E. Cassino. Price, 50 cents.

THIS little volume has been added to Dr. Granville's excellent series of small books on the mental phases of personal hygiene. They are all devoted to the conditions of mental health, and to the care of the mind under the strain and exposure of neglect, overwork, bad habits, etc. The present volume is full of miscellaneous suggestions and practical precautions in the conduct of every-day life that, if followed, will be certain to guard against trouble and increase the enjoyment of health. Dr. Granville has improved the literary form of his work as he went on, so that this last part is written in a clearer and simpler style than those which preceded it.

REPORT ON DIPHTHERIA. By FRANKLIN STAPLES, M. D., Winona. Pp. 44.

THE report includes the facts gathered by the State Board of Health respecting the prevalence of diphtheria in the State of Minnesota during two years, from November, 1878, to November, 1880. It embodies the substance of replies received from the several counties of the State in answer to inquiries sent out by the board respecting the prevalence or non-prevalence of the disease, its forms and degree of malignancy, the apparent causes and means of propagation (with express attention to the relations of the disease to water-supply and sanitary surroundings), and the means employed for its prevention. The facts collected, which are given as they were sent up, form a mass of valuable material to aid in the study of the malady. By this study the board say in the report: "We have been able to confirm many points of doctrine now generally understood concerning this disease, and, by observing its behavior on our soil, in our climate, and among the people of the various nationalities of our State, we have been able to arrive at some conclusions as to the kind of sanitary work demanded." These conclusions are given, and are not essentially different from those that have been agreed upon by sanitarians generally.

THE USE OF TOBACCO. By J. I. D. HINDS, Ph. D., Professor of Chemistry in Cumberland University, Lebanon, Tennessee. Cumberland Presbyterian Publishing House. Pp. 138. Price, 75 cents.

THIS little work presents a view of the subject adapted to popular comprehension, with arguments against the use of tobacco based chiefly on economical, hygienic, and moral grounds, which are designed to reach the public.

THE TEMPLE REBUILT: A POEM. By FREDERICK R. ABBE. Boston: D. Lothrop & Co. Pp. 251. Price, $1.25.

BY the "temple" the author typifies the soul of man, which has been cast into ruins by sin, and is rebuilt on the new foundation of the plan of salvation as laid down by Christ, by the Christian virtues and graces serving as builders, and using prayer and good works as their implements.

INCANDESCENT ELECTRIC LIGHTS, WITH PARTICULAR REFERENCE TO THE EDISON LAMPS AT THE PARIS EXHIBITION. By COMPTE TH. DU MONCEL and WILLIAM HENRY PREECE. With other Papers. New York: D. Van Nostrand. Pp. 176. Price, 50 cents.

A VOLUME of "Van Nostrand's Science Series." It has been called out by the public interest in the growth of the Edison and other systems for maintaining a steady electric light of low intensity. Besides the paper of Compte du Moncel and the address of Mr. Preece, which give the title to the book, the volume contains articles on "The Economy of the Electric Light by Incandescence," by John W. Howell, and on "The Steadiness of the Electric Current," by C. W. Siemens.

PUBLICATIONS RECEIVED.

The Wings of Pterodactyls. By Professor O. C. Marsh. Pp. 16. With Plates.

Nature the One and Only Deity; and Humanity in its Entirety, in all its Stages of Being, Nature's Highest Expression. By John Franklin Clark. Boston: Colby & Rich. Pp. 16.

Contributions to the Chemical Laboratory of Harvard College. By Henry B. Hill. Pp. 32.

The Daggatouns, a Tribe of Jewish Origin in the Desert of Sahara: A Review. By Henry Samuel Morais. Philadelphia: Edward Stern & Co. Pp. 14.

Consumption: Is it a Contagious Disease? What can be done to prevent its Ravages? By Bela Cogshall, M. D. Flint, Michigan. Pp. 12.

The Importance of introducing the Study of Hygiene into the Public and other Schools. By Stanford E. Chaillé, M. D., Professor of Physiology, etc., University of Louisiana. New Orleans. Pp. 20.

Annual Report of the Board of Health of the State of Louisiana to the General Assembly, for the Year 1881. New Orleans. Pp. 427.

Little-Known Facts about Well-Known Animals: A Lecture. By Professor C. V. Riley. Washington: Judd & Detweiler. Pp. 32. 10 cents.

State Education. By Charles S. Bryant, A. M. Pp. 16.

On Some Hegelisms. By William James. Cambridge, Massachusetts. Pp. 24.

Notes of Work by Students of Practical Chemistry in the Laboratory of the University of Virginia. No. X. Communicated by J. W. Mallet. London. Pp. 15.

Transactions of the Seismological Society of Japan. Vol. II. July to December, 1880. Tokio: "Japan Mail" Office. Pp. 103. With Charts.

Journal of the American Chemical Society. Vol. III. New York: Lehmaier & Bro., printers, 95 & 97 Fulton Street. Pp. 110.

A Study of the Various Sources of Sugar. By Lewis S. Ware, Member of the American Chemical Society, etc. Philadelphia: Henry Carey Baird & Co. Pp. 66. 50 cents.

Bacillus Anthracis. By George M. Sternberg, Surgeon, United States Army. New York: Thompson & Moreau, 51 & 53 Maiden Lane. Pp. 4. With Plate.

Experiments with Disinfectants. By George M. Sternberg, Surgeon, United States Army. Pp. 12.

A Contribution to the Study of the Bacterial Organisms commonly found upon Exposed Mucous Surfaces, and in the Alimentary Canal of Healthy Individuals. By George M. Sternberg, Surgeon, United States Army. Pp. 24. With Three Photo micrographic Plates.

The Silk-Worm: Being a Brief Manual of Instructions for the Production of Silk. By C. V. Riley, M. A., Ph. D. Washington: Government Printing-Office. Pp. 37. Illustrated.

Guide to the Flora of Washington and Vicinity. Washington: United States National Museum. Pp. 264. With Map.

Civilization in its Relation to the Decay of the Teeth. By Norman W. Kingsley, M. D. S., D. D. S. New York: D. Appleton & Co. Pp. 10.

Geologie des Eisens (Geology of Iron). By E. Reyer. Vienna, Austria. Pp. 19.

Some Remarks on the Tastes and Odors of Surface Waters. By William Ripley Nichols. Boston: Society of Civil Engineers. Pp. 16.

Utah and its People: Facts and Statistics bearing on the "Mormon Problem." By a Gentile. New York: R. O. Ferrier & Co., 62 Vesey Street. Pp. 48.

Natural Filtration at Berlin. By William Ripley Nichols. Boston. Pp. 8.

History and Causes of the Incorrect Latitudes as recorded in the Journals of the Early Writers, Navigators, and Explorers, relating to the Atlantic Coast of North America, 1535–1740. By the Rev. Edmund F. Slafter, A. M. Boston: Privately printed. Pp. 20.

Intermittent Spinal Paralysis of Malarial Origin. By V. P. Gibney, A. M., M. D. New York: B. Westermann & Co. Pp. 20.

Annual Report of the Connecticut Agricultural-Experiment Station for 1881. New Haven, Connecticut: Tuttle, Morehouse & Taylor. Pp. 122.

Proceedings of Meetings held February 1, 1882, at New York and London, to express Sympathy with the Oppressed Jews in Russia. New York: Industrial School of the Hebrew Orphan Asylum. Pp. 50.

The Orthoëpist. By Alfred Ayres. Twelfth edition, revised and enlarged. New York: D. Appleton & Co. 1882. Pp. 208. $1.00.

The Ventilation of Coal-Mines. By W. Fairley, M. E. New York: D. Van Nostrand. 1882. Pp. 95. 50 cents.

The Student's Guide in Quantitative Analysis. By H. Carrington Bolton, Ph. D. New York: John Wiley & Sons. 1882. Pp. 127. Illustrated.

The Medical Adviser in Life Assurance. By Edward H. Sieveking, M. D. Philadelphia: P. Blakiston, Son & Co. 1882. Pp. 196. $2.

Operations of the United States Life-Saving Service for the Fiscal Year ending June 30, 1881. Washington: Government Printing-Office. 1881. Pp. 428.

Consular Reports, Nos. 1, 2, and 3. 1880 and 1881. Washington: Government Printing-Office. 1881. Pp. 600.

Comparative New Testament; Old and New Versions, arranged in Parallel Columns. Philadelphia: Porter & Coates. 1882. Pp. 690.

Report on the Geology of the Henry Mountains. By G. K. Gilbert. Washington: Government Printing-Office. 1880. Second edition. Pp. 170. Illustrated.

POPULAR MISCELLANY.

Sewerage of Large Villages.—Mr. James T. Gardiner, Director of the New York State Survey, has made a valuable report to the New York State Board of Health on the methods of sewerage for cities and large villages. He finds, after inquiry, that where, in general, intelligent efforts have been made to produce proper sanitary conditions for towns, cess-pools and vaults have been abolished, and the sewage is removed from the neighborhood of dwelling-houses by dry removal, or by water-carriage or sewerage. The efficiency of the system of removal by means of the dry earth-closet depends upon constant proper attention. In practice, it is found that the provision of fine, dry earth, and the constant intelligent surveillance necessary, can not be secured from any but

exceptional families. The system can not, therefore, be safely recommended for towns in which a large proportion of the people are always ignorant and careless. The tub, cask, or pail system, which is used even on a large scale in England, France, and Germany, "is undoubtedly the best method of removal, where towns have neither water-supply nor sewerage." In this system, the refuse matter is allowed to fall into a tub or cask, which is removed, emptied, cleaned, and disinfected by the town authorities at least once a week. At Manchester, England, sifted ashes are added during use to the contents of the tub, as a deodorizer. This system is successfully employed at Manchester and Rochdale, England, at an expense of $95 per thousand persons, or ten cents per person per annum; and is recommended for villages which can have no general water-supply. The weakness of it is, that the removal, cleansing, and disinfecting of the tubs require constant care and expense, and may be neglected by careless, ignorant, or parsimonious village authorities —a weakness rather attributable to village authorities than to the system—but under no circumstances could the evils of such neglect be comparable with those of privy-vaults. The system is, however, unavoidably inferior to that of sewerage, in that it does not provide for the removal of waste-water and slops. Mr. Gardiner expresses a decided preference for the "separate" system of sewerage, which is adapted to carry off slops alone, to the "combined" system, in which the attempt is made to carry off both slops and storm-water by means of one set of conduits. He regards the separate system as vastly cheaper than the combined, and as very much more wholesome, in that it does not supply the territory for the cultivation of the bacteria that find rich and extensive propagating grounds on the moist, unglazed walls of the large combined sewers. A conspicuous example of the successful application of the separate system is found at Memphis, Tennessee.

Origin of the Sun's Light and Heat.—Dr. H. R. Rogers, of Dunkirk, New York, has come forward with a criticism of the existing theories of the origin of the light and heat of the sun from combustion, mechanical action, or shrinkage of the sun's mass, as insufficient and not adequately supported by the analogies of any facts with which we are acquainted, and has advanced a theory that they are the result of electrical action. The sun, he believes, is a cold body, like the earth, but so constituted and so situated relatively to the earth that a stream of electric currents is constantly passing between the sun and the earth. These currents reach their points of greatest intensity within our atmosphere, where all the manifestations of force which we assign to the sun's surface really take place. Dr. Rogers also believes that the phenomena of gravitation may be traced to the same origin.

The Germination and Vitality of Seeds.—Dr. Richard E. Kunze, has collected a number of facts respecting the germination and vitality of seeds, in an essay which was read by him before the Torrey Botanical Club last December. Some seeds, to grow, must be planted immediately on maturity. Familiar examples are those of the elm and maple, the oak, and most of our common nuts. The seeds of the larkspur (*Delphinium formosum*), of some gentians, and of *Angelica*, partake of this character. Spanish chestnuts and filberts, however, have been sent, enveloped in wax, to the Himalayas, and plants from them are now growing there. Seeds of the *Victoria regia* had to be transmitted from America to England in water before the first plant was raised that came to perfection. Bosse, a German horticulturist, says that, when seed is to be kept for any length of time, it should be left in its natural covering. Other means of protection are sometimes available to preserve perishable seeds. Acorns will keep, packed in the hard ground, for centuries, and many seeds may be safely kept or transported in honey. Some seeds, like those of the *Cucurbitaceæ*, the balsam, stock, and wall-flower, improve with age to a certain extent. Many seeds are capable of preserving their vitality for years under ordinary conditions of dry exposure. Experiments by M. Alphonse de Candolle indicated that woody species preserved the power of germinating longer than others, while biennials were at the opposite end of the scale,

and perennial herbs lost their vitality sooner than annual ones. Of three hundred and sixty-eight species of seeds fifteen years old, that he sowed, only seventeen germinated, and but few of the species came up. The seed of radish has grown freely at fifteen years; that of *Sida Abutilon* at twenty-five; those of melon and tobacco at forty; that of the sensitive-plant at sixty. A committee of the British Association reported in 1847, after seventeen years of examination, that the *Leguminosæ*, considered as a family, appeared to possess more vitality than any other; next came the *Malvaceæ*, *Tiliaceæ*, and Croton, of the *Euphorbiaceæ*, among those kinds whose seeds grow after ten or more years. Apparently well-authenticated instances of seeds that have grown after having been preserved from a remote antiquity are not rare. Plants have been raised from seeds found along with coins of the Emperor Hadrian, in an ancient barrow in England—*Medicago* and a heliotrope from a Roman tomb, fifteen or sixteen hundred years old, where they had been put in a bag under the head of the corpse for a pillow. The genuineness of some of the specimens of so-called "Egyptian wheat" has sometimes been questioned, but Mr. M. F. Tupper obtained plants from grains which Sir Gardiner Wilkinson took from a previously unopened mummy-case, and gave to Mr. Pettigrew, who gave them to him. Rose-seeds and doura-seeds, the genuineness of whose ancient Egyptian origin is equally well authenticated, have grown, the former with Mrs. Governor Wood, at Quincy, Illinois, the latter with the Rev. Albert Hale, of Springfield, Illinois. Professor John Henry Carroll, of the College of Archæology and Æsthetics of the City of New York, has raised Indian corn from seed taken from a Peruvian mummy supposed to be twelve hundred years old.

A Criticism of Medical Schools.—Dr. Frederic R. Sturgis, in a paper read before the Medical Society of the State of New York, strongly denounces the present systems and standards of medical education. Noticing some unfavorable criticisms that have appeared of the general culture and manners of young physicians, he attributes the origin of the condition which the criticisms expose to the unregulated management of the medical schools. They are nearly all private business enterprises, and have to look to their fees for their support. Hence, while they are always on the alert for whatever may tend to increase their fees, they are easily enough prone to neglect or overlook what may have no direct bearing upon that point, though it may be of the utmost importance in relation to the fitness of the student to become an acceptable practitioner, and a desirable acquisition to the community in which he may settle himself. The charters of medical schools are too easily obtained, and not sufficiently guarded, to make it sure that the school will be a useful agency, or even that it will not do harm. "There is nothing," says Dr. Sturgis, "making the educational candidate for a charter show just cause for its existence, nor anything binding it to give good and proper instruction; hence, as soon as its charter is obtained, it may do as it pleases—teach or not, as it likes; or, if it prefers it, may sell its diplomas." The remedy for this evil is the pecuniary endowment of schools, by means of which they may be able to limit themselves to their proper office of serving as places of instruction and nothing else, and be relieved of the necessity of making their diplomas licenses to practice, "which right ought never to have been given them." Then branches can be taught, such as public hygiene, medical jurisprudence, and the like, which have now to be passed over in silence, or else very superficially taught; and the institution which gives the best instruction will, other things being equal, receive the most students. In a word, the concern of the institution should be, in the language of President Eliot, "to have a very good school of medicine, rather than a very large one."

Provincial Accents among Deaf-Mutes.—A topic has been under discussion in the French Academy of Sciences that involves the question whether provincial accents in speech are or are not the result of local peculiarities in the structure of the vocal organs. M. F. Hément has observed that the deaf and dumb children in a certain institution, who had been taught to articulate

sounds, speak with the accent of their country; and he believes that, as they have never heard any one speak, their peculiar accent can only proceed from their having organic conformations like those of their parents. M. Hément is supported by a communication from Mr. W. E. A. Axon, published in "Nature." M. Emil Blanchard, contradicting this view, cited the example of a French-speaking Chinaman with whom he had talked, who had no trouble with his *r*'s; and he suggested that the question could not be considered satisfactorily solved till a number of children of people speaking peculiar idioms had been separated from their parents from birth, and taught to speak a single language. Mr. A. Graham Bell has communicated a paper to the "Academy," stating that, in observing the pronunciation of at least four hundred deaf-mutes whom he had taught to speak, he has never remarked any tendency of the kind described by M. Hément. In some cases, it was true, dialectic accents could be detected; but he has always found, on investigation, that such children had been able to speak before they became deaf. M. Hément declares that his opinions are not shaken by Mr. Bell's observations, and even professes to find in them new arguments in support of his own theory.

Insect Enemies of Forest and Shade Trees.—Dr. A. S. Packard, Jr., of the United States Entomological Commission, has published a valuable report on insects injurious to forest and shade trees, which is intended, not so much to embody the fruits of any original research, as to give a summary of what is up to this time known of the habits and appearance of such insects as are injurious to the more useful kinds of trees. The amount of knowledge we have on the subject is really scanty enough, and the report is, therefore, largely a simple list of the insects that live upon our more important forest-trees. The matter is eminently worthy of the attention of farmers and gardeners and others, who have the opportunity and are competent to make intelligent investigations relative to it and inform naturalists of what they find out; and such persons are invited to communicate the substance of their observations to the commission. Much has been done in France and Germany, both of which countries possess valuable illustrated works on forest-insects. Kaltenbach, in his work on the insect enemies of plants, describes astonishing numbers of insects as found on some kinds of forest-trees, only a comparative few of which are, however, particularly destructive. Thus, 537 species are injurious to the oak, and 107 are obnoxious to the elm; the poplars afford a livelihood to 264 kinds; the willows yield food to 396 species, the birches harbor 270, the alder 119, the beech 154, the hazel-nut 97, and the hornbeam 88. Among the coniferous trees, the junipers supply 33 species, and 299 species prey upon the pines, larches, spruces, and firs collectively. In France, Perris has observed more than one hundred species either injurious to the maritime pine or living upon it without being especially injurious to it. The number known to attack the different kinds of trees in the United States is sufficiently large to excite great fears for the future prosperity of our diminished forests unless some means are found to check their increase, and the subject of forest entomology is becoming one of really great importance.

Domestication of Wild Ducks.—Mr. Charles Linden has made report to the Buffalo Society of Natural Sciences of the experiments which Mr. George Irwin, of Mayville, on Chautauqua Lake, has been conducting for more than thirty years in the domestication of several species of wild duck. A suitable lot of about an acre in extent, on the edge of the lake, was fitted up with protecting sheds and nesting-places, and stocked from time to time with eggs for hatching, ducklings, and old birds. The pin-tail and American swan freely bred and raised their young in the inclosure, without any more restraint than was necessary for safe-keeping, but were never fully domesticated, nor even transferred from the breeding-pen to the barn-yard. The dusky duck and mallard, which proved most tractable for domestication or complete metamorphosis into tamed barn-yard fowl, resisted all efforts for this purpose if they were transferred to the pen when one year old, but were readily tamed when they were raised from eggs or capt-

ured young. "The majority of them seemed to feel as much at home here as in any nesting-ground of their own choice, and generally returned whenever they were permitted to migrate in autumn." The progeny of the Canada goose as well as of the other species prospered well and became large. Some of the progeny are still living, and betray in many instances a tendency to revert, as to plumage, but the majority have become completely metamorphosed into barn-yard fowl. No hybrids from different species were obtained, except from crosses between the mallard and the dusky duck. The food of all the ducks was what they ate in the wild state—grains, acorns, etc.; and shoots and roots of aquatic plants for the wood-ducks. All the species experimented with migrated southward, if not maimed, each autumn, and invariably returned with a male mate, which remained till the female began to hatch, when it went away, never to return. The crosses obtained with tame birds retained their original plumage to a greater or less degree, but were of increased size. It appears from the experiments that the majority of our wild ducks are not easily prone to change their wild condition for that of perfect domestication, but that they manifest no aversion to breed freely, even when they are placed under artificial restraints.

Siberian Products.—The following facts indicate that Siberia may be destined to occupy a place of considerable importance in the world's trade: Gold, silver, platinum, lead, copper, and iron are found in the Ural. The gold product of that region (nearly all of it being drift-gold) amounted in 1876 to between 140 and 150 centners; and the whole product of Siberia in 1877 was estimated at about 780 centners. Coal-beds exist in the Ural, in the Kirghiz steppes, on the northern borders of the Altai Mountains, on Lake Baikal, and on the Amoor River. Graphite-beds have long been worked in the Shian Mountains, and other graphite beds are waiting exploitation on the lower Tunguska. Agriculture and cattle-raising do not flourish, notwithstanding some favoring circumstances, on account of the deficiency of outlets and labor. The fur-trade is not so important as it formerly was; for the silver-fox, ermine, and sable have become scarce. The fisheries afford an important article of export, but they are carried on in the most primitive manner. The opening of the Arctic Ocean to navigation and the extension of the railroad that now reaches to Ekaterinburg will be of great advantage to the future of Siberia.

Miracles not out of Date.—Dr. Giordano has reported upon a remarkable epidemic of morbid fanaticism which is prevailing in the village of Alia, in Italy. The place is almost inaccessible, having but little intercourse with the world, and is marked by a barbarous style of living, and by the prevalence of intermarriage, with its usual concomitants of weak-mindedness, morbidness, and idiocy; consequently, superstition flourishes. After a long drought in February, March, and April last, a religious procession was organized to obtain rain. The statue of Saint Francis was carried round, and the declaration of a fanatic that he saw water flowing on the face of the saint was readily taken up by the credulous crowd. The miracle was attributed to the intercession of a girl named Rosalia Giallonbarda, who, having formerly suffered from epilepsy, believed she had been cured by the saint, and was the subject of an excessive mysticism, with hallucinations. Her frenzy was caught by her relatives and neighbors, and spread abroad till the crowds of fanatics coming to visit her and the saint became so formidable that she was arrested. This "sacrilege" only stimulated the popular excitement.

Silk-spinning Spiders.—The spiders, large *Epeiridæ*, which produce silk, inhabit the hottest countries. They are represented in our latitudes by a few species of inferior size, the most common of which, the *Epeira diadema*, is very numerous in gardens in the fall, and may be remarked by the regularly shaped webs which it weaves among the bushes. These delicate gauzes, however, give only an imperfect idea of the webs that are woven by the larger species of tropical regions. In India, the Sunda Islands, Madagascar, Réunion, and Mauritius, the *Epeiræ* construct webs of extraordinary dimensions, and the traveler has fre-

quent cause to admire the threads which he finds strung across the water-courses, and fastened to the trees on the opposite sides. The threads of these spiders are of different kinds, and proceed from different glands. The silk which is wrapped around the cocoons is not the same that is spun in the webs, and may be of an entirely different color. The silks of various *Epeiræ* were brought to Europe by travelers in the seventeenth century, and excited admiration by their fineness and brilliancy. Experiments were tried in making cloth and gloves from them, but they were found to have no powers of endurance. Louis XIV, wishing to encourage a new art, had a coat made of the silk, but was glad to take it off the first day, for it suffered a rent every time he moved. These efforts appear to have been made with the silk of the webs. That unrolled from the cocoons proved to be stronger. M. Bon, in 1709, carded from the cocoons a silk which he described as much finer and stronger than ordinary silk, and which, he claimed, was fitted to make any kind of fabrics. In Spain, Raymondo María de Tremezer, between 1777 and 1791, made several articles as bright and fine as silk from the threads of the *Epeira diadema*. Mr. Rolt, an English merchant, was able to exhibit to the Society of Arts a specimen thread twenty thousand feet long, that had been spun by twenty-two spiders in less than two hours, and which was five times as fine as the thread of the silk-worm! Alcide d'Orbigny asserted that he had garments, able to sustain considerable wear, made in South America from spiders' silk.

Food and Civilization.—M. Beketoff, a Russian hygienist, has expressed some novel views in a paper on "The Alimentation of the Human Race in the Present and the Future." Physiologists are accustomed to consider a mixed diet, of which meat shall constitute about one third, to be the best for mankind in general, and to be almost essential to the best development. M. Beketoff does not consider this view to be well founded, or sustained by the facts as they appear on examination of the diet of the best races. A large majority of mankind do not use meat, nor a mixture of meat and vegetables, but vegetables alone, as food. The people of Europe consume more meat than those of any other part of the Old World, but most of it is used in the cities, while the country people enjoy only a small fraction of the quantity which the physiologists say they need, and it has come to that point that, in the most civilized part of the world, meat is only not wholly left out of the list of common foods. In the most populous and most civilized parts of Asia, as in China and India, cattle-raising is quite insignificant, and in Japan can hardly be said to exist at all. The Africans raise cattle, but live chiefly on vegetables. Only in North and South America and Australia is meat consumed on a really large scale. Not only the relative, but the absolute number of cattle also, shows a tendency to diminish as the population increases and the ground is more devoted to tillage; so that the prospect is apparent that, with the continuous development of agriculture, industries, civilization, and population, cattle-raising will pass into real insignificance, and the mass of men will be unable to obtain animal food. Sources of vegetable food must be found, to supply its place, among the plants richest in albuminous substances. The legumes are the most prominent of these plants. To determine the power of beans to sustain all the functions of life, Dr. Virochiloff performed a series of experiments upon himself, by eating regularly equal quantities of bread and sugar, and adding to them for a certain time meats, for another period peas. The result was, in his own words, that "both the mixtures quite fulfilled the purpose of nutrition, as was proved by the same weight of body being kept up and the forces being maintained in the same state by either food." The meat-mixture was, however, assimilated more readily than that of which the peas formed a part. It is affirmed that men occupied in intellectual work especially need a mixed food; but of this we are not certain, not knowing on what those whose intellectual achievements have been greatest have really lived; and many of them have been very irregular eaters. Taking the history of the human race as a whole, we may observe that races living almost exclusively on meat have been and are the most savage ones. The prehistoric "finds" show that the beginnings

of civilization and of the cultivation of plants kept pace with each other. This does not prove that a meat diet is opposed to civilization, but that the necessities of people who are dependent on meat for food hinder advance in civilization. They have to be hunting, and wandering about from place to place. It is when they have learned to till fields and tame animals, and have become fixed in homes, that they find time to cultivate arts. The Arctic savages are fish-hunters, the barbarians of the Asiatic steppes depend on their herds, the meat-eating Turks and Mongols were more barbarous than the vegetable-eating Hindoos they conquered, and were the authors of the woes of that suffering people. M. Beketoff's conclusion is that a vegetable diet contributes more than any other to the intellectual development of a people, while a wholly animal diet determines a kind of life incompatible with progress. A mixed diet has not been the promoter of civilization, for the most highly gifted authors have often drawn their physical forces from a wholly vegetable diet. Finally, "the great thing is evidently not the kind of food, but the kind of life that the food determines."

Synthesis of Indigo.—One of the most important of the recent discoveries in chemistry is that which Baeyer has made of a practical process for the artificial production of indigo. The successful experiments of this chemist had been foreshadowed by the production of alizarene, the coloring principle of the madder-root, from the anthracene of coal-tar; by the discoveries by Fritsche of the relations of indigo with the benzene ring and the amido-group; by Erdmann and Laurent's discovery that indigo on oxidation yields a crystalline body possessing no coloring power, to which they gave the name of *isatin*; and by Baeyer and Emmerling's accomplishment of the reverse process of reducing isatin to indigo. Three processes have been employed for the synthesis of indigo, of which, however, only one, by Baeyer, is of practical importance. The three processes have in common that they all proceed from some compound containing the benzene nucleus; that they all start from compounds containing a nitrogen-atom; and that they all commence with an ortho-compound. They differ from each other in that Baeyer's process requires the abstraction of an atom of carbon, while of the others one requires the addition of an atom of carbon, and the second starts with the right number of atoms of carbon. Baeyer's successful process, which may be called the manufacturing process, starts from cinnamic acid, a substance which is contained in gum-benzoin, balsam of Peru, and a few other aromatic bodies, but which can be obtained more cheaply by manufacturing it artificially. Bertagnini has obtained it from oil of bitter almonds; and other processes for the same purpose have been carried out. One of the processes most likely to be adopted is that of Dr. Caro, who converts toluene, by adding chlorine, into benzylene dichloride, and treating the latter substance with sodium acetate, forms cinnamic acid and sodium chloride. The next steps in the process are the formation from cinnamic acid of ortho-nitro-cinnamic acid; the conversion of this into its di-bromide; the separation from this of the two molecules of hydrobromic acid, which gives rise to ortho-nitro-phenyl-propriolic acid; and, lastly, the conversion of the latter product into indigo by heating its alkaline solution with grape-sugar, xanthate of soda, or some other reducing agent. The actual yield of indigo by the last reaction has not been made equal to what is demanded by theory, it being only 48 per cent, while the theoretical yield would be 68 per cent. The artificial production of indigo by this process may be considered as within reasonable distance of commercial success, for the ortho-nitro-phenyl-propriolic acid, the colorless substance which, on treatment with a reducing agent, yields indigo-blue, is already in the hands of the Manchester calico-printers, and may be obtained at the price of six shillings per pound of a paste containing 25 per cent of the dry acid. Indigo can not, however, be made profitably from this product till the theoretical yield can be obtained from it, and until the price of the dry propriolic acid can be reduced to 20*s.* per kilo, or 8*s.* ($2.00) a pound. The process may, however, be found applicable with advantage even at present rates, for uses for which natural indigo is unfitted. Of the other processes for manufacturing indigo,

the first starts from ortho-nitro-benzoic acid, which yields isatin after successive treatment with phosphorus pentachloride, silver cyanide, caustic potash, and nascent hydrogen. The other, also by Baeyer, starts from ortho-nitro-phenyl-acetic acid, which, having been obtained synthetically from toluol, is converted into the amido-acid, then by the loss of water into a body called oxindol, from which isatin, and therefore indigo, can be obtained.

Tobaccoism.—M. Thorens has published some observations on *angina pectoris* caused by tobaccoism. His attention was called to the subject by the case of a patient who had most of the symptoms of angina pectoris, but in whom no cause for the affection could be found except excessive smoking. The patient smoked cigarettes, and swallowed the smoke, thus making the whole quantity of smoke pass through the lungs. Evidently the opportunities given for the absorption of smoke and nicotine in this case were colossal in comparison with those which would exist in a person smoking ten times as much, but in an open place and without swallowing the smoke. Another circumstance aggravating the affection was, that the patient smoked his cigarettes directly, without the intervention of a holder, so that the smoke reached his mouth hot, without any chance having been given for the condensation of any of the volatile products. His mouth was, moreover, in constant contact with the tobacco-leaves, so that the liability of absorption by the buccal membrane was greatly increased. Similar affections arising from similar causes had been noticed by Beau and M. Gélineau, a naval surgeon, both of whom observed that the trouble was mitigated when the use of tobacco was moderated. The case suggests a number of precautions to be observed by persons who will smoke but desire to do themselves as little harm as possible, among which are never to swallow or inhale the smoke; to avoid smoking in an inclosed place, or at least to have the room as large and as well ventilated as possible; and to put as considerable a distance as is practicable between the light and the mouth, always using for this purpose long-stemmed pipes or cigar-holders. The driest tobacco and that which is weakest in nicotine, should be preferred. M. Thorens exonerates tobacco from the charge of producing cancer, although it is of course liable to irritate a wound already made, or a surface that has already been injured by heat.

The Horse in America.—It has been generally believed that the horse was introduced into America by the Spaniards. Professor Marsh, on the other hand, has found abundant remains of probable ancestors of the horse in our Western geological formations; so that, if there were no horses before the Spaniards came, there must have occurred a failure of the race. Mr. E. L. Berthoud, of Golden, Colorado, believes that he has evidence that the Spaniards found horses in South America when they first visited it. Among the maps which he has recently received from Paris, in a collection of the fifteenth and sixteenth centuries, is one which Sebastian Cabot drew for the Emperor Charles V, representing his explorations of the La Plata and Paraná Rivers, and containing symbols of the animals and plants that he found. Among these symbols was that of the horse represented near the plains of the Gran Chaco, where the immense herds of that animal range to-day. He claims that this affords a fair presumption of the native origin of the race, for neither the Spaniards nor the Portuguese had then been long enough in the country (in 1527) for their horses to have escaped from Peru to the head of the Paraguay and Paraná Rivers and to have increased in numbers sufficiently to attract attention.

The Protective Organs of Plants.—Dr. A. Tschirch has recently published some interesting observations on the relations of the anatomical structure of plants to climate and location. In the first place, the adjustment of the breathing-pores appears to be adaptable to a variety of external conditions in different plants of the same family. In plants that grow in a moist atmosphere, the pores are exposed with but slight protection; while the means of protection appear to increase gradually as the habitat becomes drier, and reach the highest point in desert plants. The closed cells

that lie partly outside of the epidermis enjoy the least protection, as in certain ferns, while a higher degree of protection is given when the cells are sunk beneath the epidermis and framed in a kind of funnel; and the highest degree when the stomata are arranged in rings or ovals on the under-side of a rolled leaf. Another means of protection is afforded by the structure of the epidermis, which is fortified by a strong cuticular structure, hardly permeable to vapor in many Australian plants, and is sometimes re-enforced by deposits of oxalate of lime. Such structures are peculiar to plants which have to sustain great drought. The epidermis of many plants, as the *Eucalyptus globulus*, is also covered with a coating of wax, which serves not only to protect it, but also to give a deeper setting to the pores. The protective effect of hairs operates in several ways: they cover the pores; they form a kind of space over the pores in which air and vapor may collect; and they constitute a kind of screen over the whole body of epidermis-cells against insolation and desiccation. Thus, plants growing on high, dry mountains, or in the steppes, are generally thickly haired. Hairs also serve to make the plant measurably defiant of sudden changes of temperature, and form an important part of the vegetable economy of regions like Soodan and continental Australia, which are subject to such changes. Even in temperate climates, varieties of the same species growing in open and exposed places are more hairy than those growing in protected woods. In the eucalyptuses the intercellular spaces and air-passages of plants growing in dry situations are much contracted, while in those growing in valleys and along rivers they are expanded. Willkomm has called attention to the fact that a sap strong in saline solutions is much less subject to evaporation than a thinner sap; and thus the *halophytes* keep fresh in stony places and the driest climates, while the *Chenopodiaceæ* (goose-foots), with much salt in their juices, flourish in dry places, and are met abundantly in the Asiatic steppes and the interior of Australia; and these look green and vigorous in the driest time of the year, when everything else is parched and brown. The form and position of the leaf also often show an adaptation to help the plant resist drought. Plants having to grow in a dry climate generally exchange the usual broad leaves for a narrow, close one, have it reduced to a cylindrical form, or, as in the brooms, make a green limb serve them as the assimilating organ. Broad leaves are seldom found in very dry regions. Many species peculiar to hot and dry situations have a faculty of arranging their leaves vertically, so that only the edge is exposed. The *Lactuca scariola*, the only European plant having this peculiarity, grows on roadsides and dry hills, while all the other species of lettuce, growing in shady and moist places, and in gardens, have the leaves arranged in the ordinary way, except that *Lactuca sativa* puts out vertical leaves when it is growing in a thin soil. The ethereal oils and thorns of plants may also possibly serve some protective purpose, but this is a subject for further investigation.

Terra del Fuegians in Paris.—Eleven natives of Terra del Fuego, four men, four women, and three children, were taken to Europe by M. Waalen, who has resided for several years at Punta Arenas, Patagonia, and have been entertained at the Jardin d'Acclimatation in Paris. M. Waalen was fishing for seals in the waters of their inhospitable island when he came in contact with these savages, and succeeded, by giving them plenty to eat and treating them with tact, in getting them to stay on his vessel, whence they were transferred to a Hamburg steamer on its way to Europe, M. Waalen depositing security with the governor of Punta Arenas for their safe return after making their European tour. What mark their visit will make upon them, and how long it will endure, is a question which the experiment of Captain Fitzroy may help to answer. He took back three Fuegians, two men and a woman, after they had been three years in Europe, and had seemed to become nearly civilized, and set them among their tribe, in a good house, with a tract of tillable land, tools, and a missionary to take care of them. Going back to see them a few months afterward, he found all that pertained to civilization destroyed, that they had returned to complete savagery, and that the missionary was

anxious to get away from them. The Fuegians in Paris are described as accustomed to squat for hours, without moving, around a fire on the lawn, perfectly indifferent to everything, and listlessly looking at the crowd who peer at them through the bars of the fence as if they were some extraordinary animals, and as occasionally exchanging with each other the guttural cluckings which serve them for a language. Only one thing will excite liveliness in them—the desire for food.

Forms of Aurora Borealis.—Lieutenant Weyprecht, in his recent work on the observation of the aurora borealis, distinguishes between seven forms in which the light appears in the polar regions. The first form is that of almost regular arches rising or sinking from the magnetic south or north to or away from the zenith, and generally extending to both sides of the horizon. Second, are streamers of irregular form and varied appearance, appearing like bands much longer than broad, moving in the atmosphere, and nearly always bent in folds and twists; they consist either of masses of light unequally distributed along the length of the band, or of single beams of the breadth of the band closely arranged together in a direction toward the magnetic zenith, and having their intervals filled with light-masses. This form is cut away on every side, or at most touches the horizon on only one side. Of the third form are threads, extremely fine beams of light of various lengths, some of them reaching from near the magnetic zenith to near the horizon, and grouped in such a manner as to resemble a fan covering a part of the firmament. The beams are not united, but are separated by dark spaces of greater or less width. Generally, they are prolongations of a streamer, which in such case answers to the continuous lower border of the fan. Fourth, is the corona, in which the beams or light-masses are joined in a common center near the magnetic zenith, and a constant movement is maintained toward or around the same. Fifth, haze—dim, unformed accumulations of light-masses illy defined, at some point in the firmament. Sixth, the dark segment, a darker appearance, forming a segment of a circle, in the magnetic north or south, bounded by a fixed and low-seated bow of light. Seventh, the polar shine, an illumination of the polar sky, the form in which the light generally appears in middle latitudes, but which is not observed in its home. Its characteristic feature is that the rays diverge from the horizon up, while the divergence in all the other forms, if their rays can be distinguished, is in the reverse direction. The movements of the mass consist either of a rising and sinking of the rays and arches with reference to the horizon, a lengthening, and shortening, and sidewise motion of the threads, or a general change of place. The mass has also motions within itself, which may consist of undulations or flashes of the light. The undulations are waves, streamers, or partial arches, which pass along generally from the magnetic east or west, toward the opposite end of the phenomenon, and then appear to spring out from it. The flashes are the shooting of short, broad beams, with the velocity of lightning, from the streamers toward or from the zenith. They are the forerunners or accompaniments of intensive coronas, and originate in particular when a stream of rays merges into the corona.

Wyville Thomson. — The death of Sir Charles Wyville Thomson, in the fifty-fourth year of his age, is announced. He was born in Linlithgow, Scotland; began his medical training at Edinburgh University in 1845; held a Lectureship on Botany at King's College, Aberdeen, in 1850; and has occupied professorial chairs in science at King's College, Cork, Belfast, and Edinburgh, where he succeeded Professor Allman as Professor of Natural History in 1870. He has contributed many papers of merit to scientific societies and periodicals, beginning with one on the application of photography to the compound microscope, which was read before the British Association in 1850. His most distinguished service, and one by which he won an enduring fame, was as Director of the Civilian Scientific Staff of the Challenger Expedition, where he gave unremitting personal attention to the dredging operations, and the examination of specimens. He had been for some time in feeble health, and his death followed his becoming severely chilled on a visit to Edinburgh. "Sir Wy-

ville was an excellent lecturer, a most genial companion, and an excellent host," and was fond of amusements of all kinds.

NOTES.

THE Boston Society of Natural History announces that a sea-side laboratory, under the direction of its curator, will be opened at Annisquam, Massachusetts, July 1, to continue until September 1, 1882. A limited number of students can be accommodated, and the work will consist mainly of study and observation of the common types of marine animals, under the immediate care of Mr. B. H. Van Vleck, assistant in the museum and laboratory of the society. Full particulars may be obtained by addressing the curator of the society, Professor Alpheus Hyatt, of Boston.

THE French Association for the Advancement of Science will meet at La Rochelle, August 24th to 31st. The organization of the congress is already in active preparation. M. Jousset de Bellesme has published a note calling attention, as the topics most likely to attract the interest of zoölogists, to ostreiculture, which is carried on along the neighboring coasts; to termites, whose nests are found in the vicinity; and to several valuable collections of the local fauna. Among the excursions will be dredging expeditions at sea, and geological excursions under the guidance of local experts.

THE account of the late Professor Clerk Maxwell, to be published by Messrs. Macmillan & Co., will include a biographical outline, with selections from correspondence, by Professor Lewis Campbell, who was very intimate with Mr. Maxwell in early life; an account of his chief contributions to science, by Mr. William Garnett, who was associated with him as demonstrator at the Cavendish Laboratory for the last six years of his life; and a collection of his poems, some of which are already known to the public, while the greater number will be published for the first time.

JOHN CHARLES FREDERICK ZOELLNER, Professor of Physical Astronomy in the University of Leipsic, died April 29th. He was born in Berlin in 1834. After receiving the degree of Doctor of Philosophy at Basle, he devoted himself to the study of photometry as applied to astronomy and physiology. He was the author of several works on subjects related to astronomy and photometry, the best known of which is that "On the Nature of Comets." He invented the spectroscope which is generally used by astronomers for the observation of the solar protuberances and the lines of their spectrum. He was specially prominent in the later years of his life through his efforts to explain the alleged phenomena of spiritualism by means of a fourth dimension of space.

AN extraordinarily high death-rate which was recorded in London for the week ending February 11, 1882, was ascribed to the dense fogs which had been prevailing. This view is strongly confirmed by the fact that the only weeks in which similarly high death-rates have been recorded during recent years were those ending December 20, 1873, and February 7, 1880, each of which immediately followed a period of dense fog and intense cold. It is also sustained by the fact that the death-rate for the week ending February 11, 1882, in the twenty-seven large provincial towns, was more than ten per cent below that of London; which goes to show that the increase of deaths was caused by the fog rather than by the cold.

THE Popular Observatory, which was opened by M. Jaubert on the Trocadéro, Paris, in July, 1880, has been visited by several thousand persons desiring to observe the stars, more than two thousand of whom have enrolled themselves as regular astronomical or microscopic observers, or attendants on the lectures. The pupils of the Popular School of Astronomy have made a considerable number of observations, of which they have given accounts in a journal, and several of them have associated themselves to put up a laboratory at their own expense. M. Jaubert has established a popular scientific class, meeting twice a week, which is largely attended by teachers.

THE value of porcelain depends on the purity of its color, and this is dependent on the absence of dark spots in the clay, which are produced chiefly by particles of iron. These particles are now extracted at some of the French factories by means of large electro-magnets, which are kept in operation by the steam-power used in other departments of the manufacture. At Mehun three machines purify about 600 kilogrammes (or 1,500 pounds) of porcelain paste every day, the proportion of impurities found averaging about 8 kilogrammes of impurities to 100,000 kilogrammes of paste.

DR. JOSEF CHAVANNE, the Austrian geographer, estimates the mean altitude of the Continent of Africa to be 2,169·93 feet, or double the mean altitude of the Continent of Europe, which M. G. Leipoldt has estimated at 971·41 feet. According to M. Chavanne, if the Atlas range were spread over the entire Continent of Africa, it would give a height of 85·86 feet only, while the Abyssinian mountain-mass would similarly give a height of 79·72 feet.

Dr. Carl Vogt has declared, peremptorily, that "the organisms in meteorites announced by M. Hahn have no existence; what have been described as such result from crystalline conformations which are absolutely inorganic. None of the imagined organisms have the microscopic structure belonging to the organisms with which they have been associated. In particular, the asserted sponges do not show the structure of either existing or fossil sponges; the so-called corals do not show that of polops or anthozoa; and the imagined crinoids do not show the structure of known crinoids. The observed structures are due to an opaque crust, or result from optical illusions, caused by an incomplete method of conducting microscopic researches."

Signor Roncelli, of the Italian Parliament, has devised a simple and practical method of voting by electricity. Each member of the House has in front of him a metal plate bearing his name or number, on which are three buttons, marked respectively, "Ay," "No," and "Abstain." The buttons are connected with a central printing apparatus which prints in three separate columns the ayes, noes, and abstentions, according to the buttons touched by the members; while, with every addition to each column, the sum of the votes in the column is automatically recorded.

M. Delahaye has published in the "Revue Industrielle" some facts concerning extraordinary pressures of wind that have been observed in railway management in India. On the 5th of October, 1864, two trains on the Eastern Bengal Railway, one of eight cars, the other of twelve, were blown over during a violent storm. Four other cars were blown down a side-track, and overturned near the station by colliding with other cars which had also been blown there. On the 21st of September, 1878, a long freight-train on the same railway, while going about eight miles an hour, was blown back nearly a mile, although the engine had a full head of steam and the breaks were put on. Half the train was taken off, when the rest could barely make headway. The Indian railway service affords several other cases of trains that were stopped or greatly hindered by strong winds.

M. Pitre de Lisle has described a singular class of stone celts or hatchets which have been found so far only in Brittany and Northwestern France. They differ from other stone hatchets in having a knob or button-like termination on the butt or hammer end, while other hatchets taper away to a more or less conical point in this part. The blades vary in length from about three inches to about fifteen inches, and are all made of rocks belonging to the family of diorites. M. de Lisle calls these instruments *haches à tête*, or *haches à bouton*—hatchets with heads, or hatchets with buttons. He believes that the object of the expansion was to give greater security to the fastening of the blade or to the holding of it in the hand.

Sir Robert Christison, Professor of Materia Medica in the University of Edinburgh, died January 27th, in the eighty-fifth year of his age. He was the son of a professor in the university, was graduated as Doctor of Medicine in 1819, and became Professor of Medical Jurisprudence in the university in 1822, and of Materia Medica in 1832. His specialty was poisons, on which he published a "Treatise" in 1829 that is still recognized as a work of great value. He received numerous honors on account of his eminence in his department, and held many public positions for which his gifts of knowledge and experience furnished important qualifications. He was elected to the presidency of the British Association in 1876, but declined it on account of his advanced age. He was noted in his youth as the most accomplished athlete in the university.

Besides the contributions in physical science which have, within a year or two, appeared in European journals, from Japanese students, we find that they are doing their share of the work in biological science as well. Within a few months there have appeared in the "Quarterly Journal of Microscopical Science," London, an article on the structure of the gills of *Lamellibranchiates*, by Mr. Mitsukuri; and another paper, by the same author, on the development of the suprarenal bodies in mammalia. In the "Zoologischer Anzeiger," Leipsic, Mr. Ijima gives a condensed summary of a memoir on the structure of the ovary, and the origin of the egg and the egg-string in *Nephelis;* and Mr. Iwakawa gives the results of his observations on the genesis of the egg in *Triton*. The two latter-named gentlemen have never been abroad.

A wealthy land-owner in the Tyrol has made an application of the microphone to the detection of subterranean springs. He fixed the microphones at the spots where he supposed water might exist, each being connected with its telephone and battery. Then, at night, he put his ear to each of the instruments and listened for the murmuring of the waters — and in several cases heard it.

An exposition of electricity is to be held in the Palais Royal at Munich, under the auspices of a committee, of which Dr. G. de Beetz, of the Royal Scientific School, is president.

SAMUEL STEHMAN HALDEMAN.